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Abstract

Radiological characterization of the hot cells in the 224B Building was performed in order to determine radionuclide isotopic inventory and establish operational criteria for decontamination and decommissioning (D&D) of the facility. Radiological inventories were established for the fission products: cesium-137 and strontium-90 plus cobalt-60. An estimate of the total plutonium (all isotopes) was made based on the abundance of americium-241.

Recommendations are made for general D&D worker safety, based on a general survey of the hot cells, plus smear samples taken at strategic points within the cells. The general level of exposure is low enough that no stringent precautions need be taken for entry. However, the hot cells are covered with americium-laden dust, which poses a breathing hazard to any D&D operation.

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EXECUTIVE SUMMARY

The test plan, SD-DD-TP-002, described the objectives and methods to be used in gathering data for the radiological characterization of the 224-B hot cells. This report presents the data and develops inventory estimates based on the methodology described in the test plan.

The test plan described two phases of activity: a general survey which would identify areas of interest and a detailed series of measurements to develop the final characterization. The first survey was performed by the Radiological Protection Department (RPD). Those results are tabulated on facility sketches and included as an appendix.

Following the RPD survey, the Analytical Process Development Unit (APDU) directed the detailed characterization measurements. These consisted of analysis of selected smear samples from within the hot cells, general radiation dose readings of penetrating gamma and beta fluxes, and in-place analysis of gamma emitting radionuclides with the Mobile Radionuclide Analysis Laboratories.

An inventory of the hot cells was developed based on averages of the measurements. Conservative estimates were made based on the maximum values of the sample analyses and in-place measurements where no direct data were available. The nontransuranic radionuclide inventory is 26 curies, consisting of:

1.1 curies of cesium-137,
22 curies of strontium-90, and
3.7 curies of cobalt-60.

The transuranic (TRU) inventory of 38 curies is:

5 curies of americium-241,
31 curies of plutonium-239, and
2 curies of other plutonium isotopes.

These values have an approximate error of ±200% at the 99% confidence level. An upper limit estimate is made at the three standard deviation point based on this error estimate. Over 80 percent of the inventory is due to only four tanks. These should be further measured during the D&D, individually.

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SD-DD-TRP-002

TEST REPORT

Radiological Characterization of the
224-B Hot Cells

1.0 INTRODUCTION AND BACKGROUND

Rockwell Hanford Operations (Rockwell) as contractor for the Department of Energy (DOE) is engaged in a program of decontamination and decommissioning (D&D) of surplus facilities.

One such facility is the 224-B Building in the 200 East separations area at Hanford. The building was used to process transuranic (TRU) material resulting from the fuel separations carried out at the Hanford site. There are six hot cell areas within the 224-B building, which are the primary subject of this characterization report.

Cell C was the receiving cell for product solutions from the 221-B Building and wastes generated within 224-B. Chemical processing of the crude product was performed in Cells A, D and E. The B-cell was initially a standby cell, but was also used to augment operations in D-cell. The F-cell was the final concentration area. It now contains an area called G-cell and was also the load-out area. Each of the cells has sampling basins on the second level. With the exception of C and E-cells, there is a centrifuge on the second level. F-cell has two centrifuges on the second level.

C-cell has a lower level pit, which has been flooded at some times in the past. This pit is now dry, as are all of the gutters and sumps in the cells. Entry into the cells is from the outside on the south side of the building at ground level. All cells except C-cell have a second level deck with access from the building's second floor (see figure 1).

This report presents results from data taken during an extensive sampling program to characterize the radionuclides and their locations within the facility.

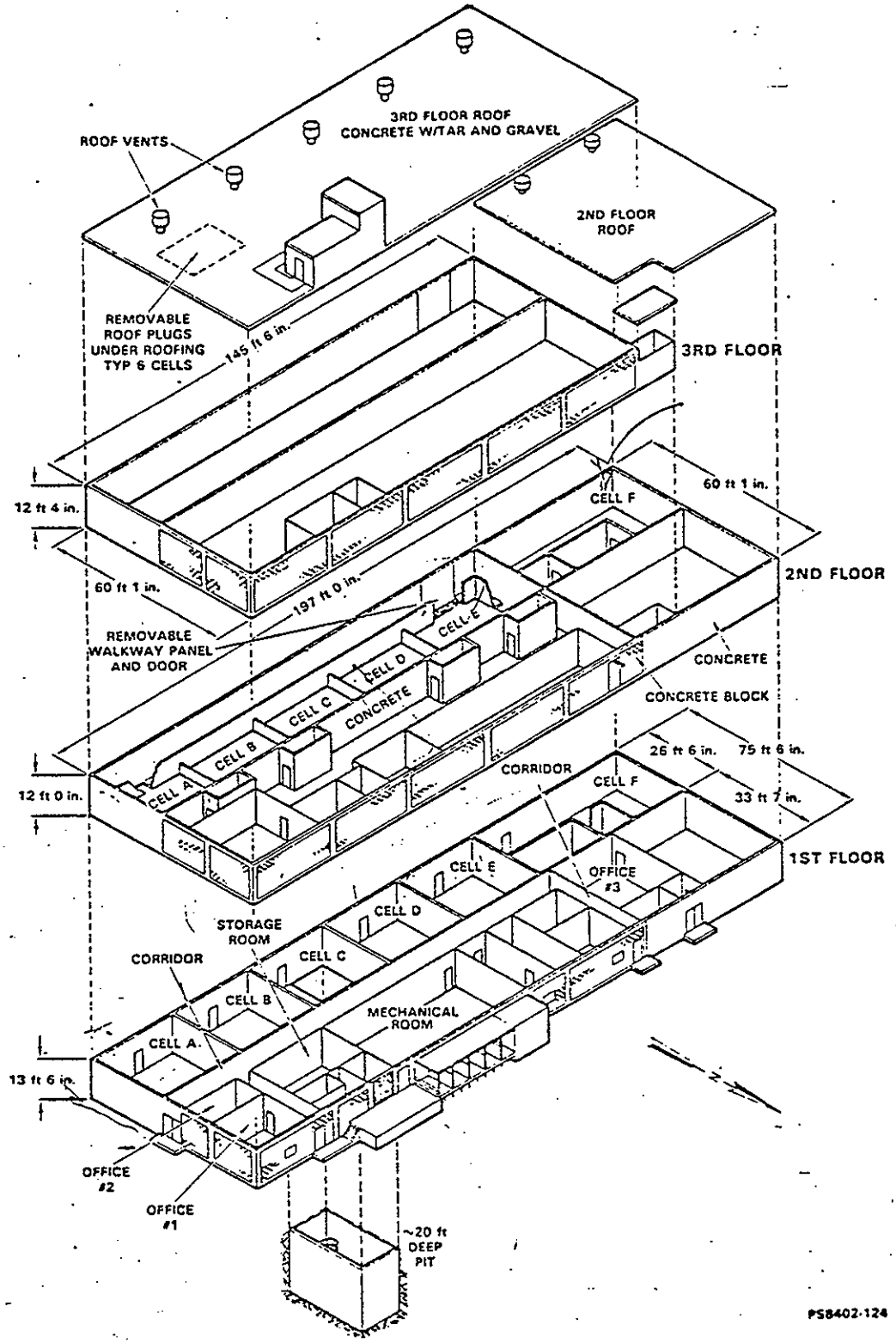

Figure 1. Exploded View of the 224-B Building, showing Hot Cells.

2.0 OBJECTIVES AND SCOPE OF MEASUREMENTS

2.1 OBJECTIVES

The objectives of this effort were outlined in the test plan (SD-UC-TP-002). Briefly stated, they were to characterize the radionuclide inventory and flux in the 224-B hot cells.

2.2 SCOPE OF MEASUREMENTS

The measurements were divided into a general survey and detailed characterization as follows:

2.2.1 General Survey

The Radiological Protection Department (RPD) made a general survey of the hot cells using standard portable monitoring equipment. This survey identified areas which were not considered radiological hazards from those which contribute significantly to the radionuclide inventory. These have contamination levels requiring D&D attention. The results were recorded on hand-drawn facility sketches (see Appendix B).

2.2.2 Detailed Characterization

Based on this general survey, the Analytical Process Development Unit (APDU) directed the taking of smear samples by the RPD and analyzed the samples for radionuclide content. The APDU also made in-place measurements within the hot cells in order

to characterize the radiological environment. These data provided the basis for a radiological inventory estimate. The data will support a work safety analysis report plus waste segregation and disposal plans prior to actual D&D of the facility.

2.3 MEASUREMENT SEQUENCE

2.3.1 Worker Exposure Levels

Initial entry was made by the RPD technician using hand instruments to check general floor, tank, and environment conditions. The APDU followed with an ionization chamber to measure the gamma and penetrating beta dose levels within the cells. Locations were noted within the cell for sampling and in-place measurements.

2.3.2 Sample Location System

A grid system was established within each cell, with each grid sector approximately one meter square. The grids are identified fully on the facility sketches in Appendix B.

2.3.3 Detailed Sampling

At least two wet and two dry smear samples were taken of the dust in each sector on the floor. Smears were also taken from the exteriors of tanks, centrifuges, miscellaneous equipment, and piping. All smear samples were checked by the RPD technician to determine which areas inside the cell contained measurable radioactive contamination.

This determined which areas would need detailed characterization for the inventory estimate. The criteria used was whether or not the sample exceeded 200 cpm with a pancake-type GM (beta-gamma) detector, or 220 dpm with a PAM (alpha) detector.* When no smear sample exceeded these limits, APDU selected one typical smear to include in the detailed analysis.

2.4 DETAILED SAMPLE ANALYSES

The APDU performed gamma energy analysis (GEA), L X-ray analysis for transuranic elements (TRU), and gross beta counting on the samples as part of the detailed characterization measurements. The analysis results are tabulated by location in Appendix A.

2.4.1 Gamma Energy Analysis

Gamma energy analysis for radionuclides was done with the Mobile Radionuclide Analysis Laboratory (MRAL-I). The measurements used a multi-channel analyzer (MCA) in pulse height analysis mode with an intrinsic germanium detector. This system is capable of determining picocurie amounts of most common radionuclides.

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* Note:

The RPD used the following portable instruments, typically: Eberline, Model BNW-1, Geiger-Mueller (beta-gamma) detector, and Eberline, Model E-140, portable alpha monitor (PAM) detector.

2.4.2 L X-ray Analysis

The MRAL-I analysis system was also used to assay for TRU isotopes by analysis of the low energy gamma rays and x-rays using the MCA and a lithium-drifted silicon (SiLi) detector. This system is capable of detecting picocurie amounts of most TRU elements.

2.4.3 Strontium-90 Sample Counting

Strontium-90 in the samples was determined by the use of a phoswich detector. The method is based on the detection of secondary beta decays from yttrium-90, the ^{90}Sr decay daughter. However, precision is not as great as other APDU systems utilizing GEA. The detection limit (+/-100%, at 95% confidence) for ^{90}Sr varies with presence of other gamma and beta emitters, but is typically about 10-20 pCi.

2.5 REDUCED SAMPLING PLAN

Following the initial sampling and smears of A-cell, the detailed plan was revised and simplified:

- Fewer grid squares were sampled in detail.
- Dust and floor debris from the square were collected first by sweeping.
- A single dry smear and two wet smears of a swept floor area were taken. This is called a triple-smear sequence.

- Within selected grid squares an in-place measurement was made to relate the residual, nonsmearable contamination to the overall cell inventory.

2.5.1 Reduced Cell Sampling

The reduced method was followed for cells B through F. The APDU analyzed the dust and debris (primarily pigeon feces) and the first wet smear, under the assumption that the dry smear would have taken the majority of the loose smearable contamination from the floor. Where the first wet smear was very high in radionuclides, the second wet smear was also analyzed. This approach indicated that significant amounts of contamination could still remain after removal of the dust in the cells and on equipment.

2.5.2 Flange Smear Samples

Exterior smear samples were made on pipe and tank flanges in all of the cells. The RPD checked the flanges on each tank, plus major piping into and exiting the cell. Where no flanges on a tank had direct readings above background, two easily accessible flanges were selected, and the triple-smear sequence was made.

Whenever a flange reading was significantly above background (200 cpm for beta/gamma) on a hand-held GM instrument or (220 dpm alpha) on a portable alpha monitor (PAM) a smear series was

taken. All tank flanges were monitored, even though not all flanges in the cells are identified in the sample data.

2.6 AIR MONITORING

During the survey a continuous air monitor (CAM) was used to collect samples of the airborne activity in each cell. The CAM was operated for 30 minutes (+/- 1 minute), with a collection rate of 6 cfm. The APDU analyzed the particulate filters for gamma-emitter radionuclide content on standard equipment in the 222-S counting laboratory.

2.7 IN-PLACE RADIONUCLIDE MEASUREMENTS

In-place measurements were made in approximately 10% of the grid locations, using high-resolution GEA systems operated by the Mobile Radionuclide Analysis Laboratories (MRAL-I and MRAL-II). Measurements were made with an area of view of about 14 inches on the floor (MRAL-I) and looking horizontally through the sidewalls of the tanks (MRAL-II).

2.8 MISCELLANEOUS MEASUREMENTS

2.8.1 F-10 Load-out Hood

The MRAL-II made one omnidirectional measurement in the sump of the F-cell load-out hood. Several smears were taken from the inside wall and inside the hood doors.

2.8.2 Ventilation Intake

The MRAL-II was used to make one measurement in front of the general building ventilation system filter. However, the RPD found only a very low level of contamination in the filter media itself. A smear was made from the dust on the filter frame near the area of highest count rate identified by the RPD.

2.8.3 Penetrating Radiation Dose Levels

A portable ionization chamber (Reuter-Stokes, model RSS-111) was used to determine general penetrating exposure rates for the survey team. Measurements were made at a minimum of three locations within the cells. These results are tabulated by locations in the cells and are included in this miscellaneous category.

2.8.4 Neutron Dose Rates

The RPD made several neutron dose rate (Snoopy) measurements at locations around the cell tanks with higher ion-chamber readings. The neutron dose rates were used only for a qualitative check on the smear results, except for the D-3 tank. Here, the neutron dose was used to verify inventory, see Appendix C. A second set of direct measurements confirmed that an earlier result was apparently a "flier." Inventory for this tank was estimated separately, see Appendix D.

3.0 RESULTS

3.1 GENERAL SURVEY

The RPD survey results, comments, and location sketches are included in the data package in the appendix.

3.2 DETAILED CHARACTERIZATION

Sequential tabulation of the detailed measurement data is given in the apppendix. The smear data are subdivided into categories of increasing concentrations:

- Smears of walls, floors, and exteriors of equipment.
- Smears of tank and piping flanges.
- Smears from gutters, sumps, and sampling boxes.
- Smears of tank and piping interiors.

Three additional categories are used to develop the inventories:

- Solids: dust and piping residue.
- In-place measurements with the mobile laboratories.
- Neutron dose measured near the tank exterior.

Data from each cell is presented and summarized according to these six categories. Each category is characterized by an average and a maximum value. The averages are used to estimate an overall inventory in Section 4. The maximum values are used to estimate distributions and error estimates for the inventory.

A summary of the analyses is presented in Table 3.1. Cesium-137, cobalt-60 and strontium-90 were the principal non-TRU radionuclides contained in the dust. Americium-241, a decay daughter of plutonium-241, is the prime TRU component identified by GEA. The plutonium total is estimated from the ratio of ^{241}Am to ^{239}Pu on those samples containing sufficient amounts of both ^{241}Am and ^{239}Pu to quantify their ratio (1:13.14). Details are given in Chapter 4. In the following sections, descriptions of the A-cell apply to all cells except as noted.

3.2.1 A-cell TRU Measurements.

The A-cell was sampled very thoroughly to determine the levels of detail required in the other cells. After analysis of the first smear samples, APDU decided that both wet and dry smear data were unnecessary. Each looks primarily at the loose material on the floor. Gamma energy analysis of dry floor smears was largely eliminated after sample 20.

Data from A-cell are presented in Appendix Tables A.1.1 and A.1.2 for TRU and non-TRU components corrected only by subtraction of background. The dust and smear samples qualitatively agree with the MRAL-I down-looking in-place measurements. No significant additional radionuclides were identified. The category averages are also presented in the same tables. These averages are used to estimate inventories presented in Chapter 4.

TABLE 3.1 224B DATA SUMMARY AVERAGES

	AMERICIUM-241 (pCi)	CESIUM-137 (pCi)	Other Ratios (^{90}Sr: ^{137}Cs: ^{60}Co)
A-cell			
Dust solids	741/g	215/g	1.05: 1: 0.25
Pipe scrapings	42400/g + (1)	577/g	3.48: 1: 0.26
Inside smears	34400 +	129	NA
Flanges	2267	56	2.28: 1: 0.53
In place	236/sqcm	15/sqcm	NA : 1: 0.18 (2)
B-cell			
Dust solids	505/g	284/g	0.77: 1: 0.39
Smears	9000 +	NA	NA
In-place	1681/sqcm +	14/sqcm	NA: 1: 0.38
C-cell			
Dust solids	472/g	394/g	16.6: 1: 10.9
Scrapings	60/g	12/g	268: 1: 6.15
Flange smears	8890 +	90 +	NA
In-place	20/sqcm	117/sqcm	NA: 1: 19.7
D-cell			
Dust solids	171/g	143/g	1.28: 1: 0.20
Inside smears	30352	198 +	32.9: 1: 7.2
(reconfirm)	1940	627	(see Appendix D)
Flanges	885	593 +	5.78: 1: 0.28
E-cell			
Dust solids	89/g	75/g	1.24: 1: 0.13
Inside smears	34820	14100 +	1.27: 1: NA
Samplers	2177	<mdl	NA
Flanges	2018	NA	NA
F-cell			
Dust solids	2326/g	1098/g	2.03: 1: NA
Flanges	9232	839 +	NA
Inplace	328/sqcm	161/sqcm	NA
Loadout hood	680nCi	18.5 nCi	NA

Note 1: The + designates a maximum value out of a limited number of samples. Detailed averages by category are in the appendix.

Note 2: NA designates a category that has too many <mdl values to adequately designate a ratio.

The maximum measurement in a sample group is also flagged. These are used to estimate distributions and errors in Chapter 4.

3.2.1.1 Walls, Floors and Equipment Exteriors

The smear samples with the least amount of radionuclide contamination are from the walls, floors, and equipment exteriors. The significance of the smear samples lies in being able to quantify the ^{241}Am to non-TRU ratios with enough data to assure adequacy of the extrapolations needed to make the inventory estimate.

o Dust Influence

This category is influenced the most by dust settling in various locations. The presence of the dust tends to obscure the fact that contamination may also be imbedded in the surface or cracks and irregularities in the surface. The average TRU content in the A-cell dust is represented by samples 33-38 inclusive, plus 119 and 120. Only one of the eight dust samples exceeded 1 nCi/g.

o MRAL-I Estimate of TRU in Floor Dust

The average concentration of ^{241}Am in the floor dust of A-cell is estimated to be 236 pCi/sq cm. This is based on the average MRAL-I in-place measurements with the swept area value subtracted.

o TRU of Nonfloor Surfaces

The walls and tank exteriors are typified by samples 41, 46, 52, 54, 60, 65, 78, 313, 315, and 323. The average value of these samples is 419 pCi. This exceeds the average dry floor smear, at 281 pCi. Also unexpectedly, the wall smear, sample 78, had more TRU than the overall average.

o TRU in the Bulk Solids

Dust sample 35 had the most ^{241}Am content. It is nearly seven times more than the group average. This variation is significant only when compared to the A-cell concentrations. When compared to the entire building, individual variations are less extreme. Errors in the facility-wide average are smaller than any one measurement. This can be seen by looking at all the dust samples in Appendix A.

o Operating Deck Samples

The second level operating deck is covered by contaminated dust much like the general floor area. The 2nd level samples contained an average of 396 pCi of ^{241}Am. There is no significant difference between the ground floor and the 2nd level dust values.

3.2.1.2 Tank and Piping Flanges

The A-cell flange data are presented on page 3 of Table A.1.1 for the A-1, A-3, and A-4 tanks plus the centrifuge. The average of all 16 flange smears is 2267 pCi. Five samples had less than

minimum detection limits of ^{241}Am. The maximum value came from a flange on the A-1 tank, which exceeded the average by a factor of 13, probably an indication of a leaking flange gasket.

3.2.1.3 Gutters, Sumps and Sampling Boxes

o Gutter TRU Measurements

The "G" grid sectors and gutter contain the greatest amounts of radioactivity. The average ^{241}Am content is 2518 pCi per smear. This is a factor of 5.3 times greater than the general floor average. The maximum smear is 219% higher than the average. This indicates that the gutter regions are not uniformly contaminated.

o Sampling Boxes

The sampling boxes are accessible from the 2nd floor vestibule. The sampling boxes appear visually to be "clean", but have residues from past usage. The boxes have noticeably less of the general dust than the rest of A-cell. The smear data is a better sample of the actual contamination resident in the walls of the box rather than in the dust, as is the case with the floor below.

o Sump

Each cell has a sump to collect drainage from the gutter. No sample of solids was taken from the sump of A-cell. Data from the sumps in C-cell and F-cell will be used to characterize the sumps and provide an inventory estimate for this category.

3.2.1.4 Interiors of Tanks and Piping

Those smears from either inside tanks or piping are called inside smears (see Table 3.1). Samples 241 and 242 represent potentially flushable material from inside the piping and tanks. They were taken after opening the A-1 tank side flange in the triple smear sequence. It is significant that the dry smear collected more than the wet one which followed. Either the residue is very loosely attached to the piping, or whatever is left after the first smear remains bound to the walls. Interior flange scrapings give the ratios of ^{241}Am:^{137}Cs:^{90}Sr:^{60}Co which are the bases for extrapolations of the radionuclide inventory.

o In-place Tank Measurements

The A-cell tanks on the first floor did not have sufficient radioactive material inside to obtain a tank-by-tank inventory. All such tanks are estimated at "less-than" values based on the in-place measurements by the MRAL-II inside tank D-4.

3.2.1.5 Adequacy of the A-cell Data

Analysis of the solids (dust, debris, and interior scrapings) did not reveal any different radionuclides in significant amounts compared to the MRAL-I in-place measurements. Therefore, the APDU feels that the general amount of data is sufficient to give both qualitative and quantitative estimates of the radionuclide inventory in the A-cell.

3.2.2 A-cell Non-TRU Measurements

Data for the non-TRU measurements are presented in Table A.1.2 in the same format as that for the TRU. Cesium-137 and cobalt-60 values were found by gamma energy analysis (GEA) of samples by the APDU. The strontium-90 component was measured by differences in window counting using a phoswich detector. Trace amounts of other fission products were also found, such as ruthenium/rhodium-106 and europium-154, -155.

3.2.2.1 Non-TRU Sample Measurements

The average values of the ^{137}Cs, ^{90}Sr and ^{60}Co smear samples are summarized in Table A.1.2 for the same categories as the TRU data. Some items of particular interest are:

- Cobalt-60 is the least abundant contaminant of the three in the A-cell samples.
- Strontium-90 is most abundant in the scrapings from inside the tanks and dust solids. However, the variation in relative ^{90}Sr content in different locations is larger than for ^{60}Co.
- Cesium-137 is the most consistent in comparing samples and smears from different locations. This is used as the basis of comparison to estimate non-TRU quantities.

3.2.2.2 A-cell Radionuclide Ratios

Enough data were collected from the A-cell to estimate the ratios of alpha/beta/gamma radiation components, using the floor smear

values of ^{241}Am: ^{90}Sr: ^{137}Cs. These ratios are 475: 68.5: 452. ^{137}Cs will be used as an indicator in the analysis in chapter 4. The non-TRU components are designated as the ratios of ^{90}Sr: ^{137}Cs: ^{60}Co. The "Indicator", ^{137}Cs, will always have the value of unity in the second position; see Table 3.1.

3.2.2.3 Non-TRU in Solids

The eight dust samples are summarized on page 4 of Appendix Table A.1.2. The activity content of both ^{90}Sr and ^{137}Cs are comparable, while the ^{60}Co content is about one-fourth as large. The $^{90}Sr/^{137}Cs$ ratio is higher than in the general floor smears. The scrapings have even greater amounts of ^{90}Sr compared to ^{137}Cs. The relatively small variation in ^{137}Cs compared to the others confirms the decision to use it as the non-TRU indicator.

3.2.2.4 Other Non-TRU Measurements

Several other observations may be noted from the tabular data.

- The second level deck is double the activity per smear in ^{90}Sr, but nearly equivalent in the other radionuclides. If this trend is also seen in each of the remaining hot cells, it may be an indication of the general source of at least the ^{90}Sr component of the dust.
- The gutter smears are higher than the general floor area in TRU. Differences are less significant for the non-TRU.

- o The flange data are similar to the scrapings from inside piping. ^{90}Sr contributes the most to the smear activity.
- o ^{60}Co has very little direct contribution to general radiation levels on the floor, as seen from the MRAL-I measurements.
- o Sweeping the floor removed a significant fraction of both ^{137}Cs and ^{241}Am, but it had no effect on the measurement of ^{60}Co by the MRAL-I.

3.2.3 TRU in Cells B, D & E

The data format for B, D, and E cells follows that used for the A-cell. The reduced sampling method and triple smear sequence was followed. Data are in Appendix Tables A.2.1, A.4.1, and A.5.1.

3.2.3.1 Comparison with A-cell Data

o B-cell Smears

Several smears collected more TRU contamination than from corresponding locations in A-cell. Four of the flange smears are over 2000 pCi of ^{241}Am. The non-TRU values are negligible, however.

o Other B-cell Measurements

The dust samples have about the same concentrations as in A-cell. This indicates that they may have had similar sources. The in-place measurements in the center of B-cell indicate a very high amount of ^{241}Am. When the collimating cone was removed, the ^{241}Am photopeak intensity increased markedly. It is probably

^{241}Am photopeak intensity increased markedly. It is probably "shine" from one of the tanks. However, the MRAL-II horizontally collimated detector was not sensitive enough to measure the ^{241}Am tank residue in a directional mode to confirm any one tank as the source. We have to estimate the ^{241}Am content based on other tank averages, plus the ratios from the interior smears.

o D-cell Smears

Data from the floor smears in D-cell follow the general pattern for A-cell, but with reduced ^{60}Co values. The flange smears have high amounts of ^{241}Am, followed by significant amounts of ^{90}Sr. Cesium-137 concentrations are relatively uniform.

o D-cell dust

The dust samples are uniformly low in ^{241}Am concentration. All have values of less than 1 nCi/g. The floor inside of this cell was not measured with the MRAL-I down-looking detector because of the relatively low concentrations in the dust samples.

o Tank Interiors

The D-4 tank cover was removed, and several interior smears were taken by the RPD. Two smears, 140 and 144, are of interest. The dry smear collected only a modest amount of ^{241}Am, but the wet one had much more activity. This is an indication that the

tank interior contamination is not particularly loose, but that it may be washed off easily.

o MRAL-II In-place Measurements

Activity in all of the large tanks was measured using the MRAL-II collimated borehole detector. This detector/collimator has a round window, with a maximum viewing angle of approximately 45 degrees. The omnidirectional ^{137}Cs concentration was converted to this field of view and assumed to originate wholly from the closest tank wall. The attenuation of 662 keV gamma rays due to the thickness of the tank wall plus steam jacket is used for estimating the final net concentrations. The first measurement into the D-3 tank seemed to be a "flier" and was reevaluated, see Appendix D.

o D-cell Gutter

The D-cell gutter was very low in smearable contamination.

o E-cell Dust

The dust from E-cell was the lowest in overall activity of any cell. No floor measurements with the MRAL-I were taken in the E-cell because of the low values.

o E-cell Smears

The E-cell tank flange smears had more ^{241}Am than those in A-cell and the same order of magnitude as those in D-cell. This agrees

with the cell use order, in which the TRU product was processed. The smear from inside tank E-4 was much lower in value than the corresponding one in tank D-4. Significant amounts of both ^{90}Sr and ^{241}Am were found on smears from inside the E-cell centrifuge. In estimating the 224-B building inventory, the centrifuges will be treated just as if they were tanks.

3.2.4 Non-TRU in Cells B, D and E

Sample data are tabulated in Appendix Tables A.2.2, A.4.2 and A.5.2. The activity concentrations in dust from these cells were lumped together with those from A-cell for estimating inventory.

- Cobalt-60 remains the least concentrated of the radionuclides in both the dust and smear data.
- There were large amounts of ^{90}Sr inside the tanks and piping found by the wet smears.
- With the exception of sample 246, the ^{137}Cs content in the smear samples remains less than 1 nCi. Even the inside of the centrifuge drain was very low in ^{137}Cs.

3.2.5 TRU Measurements in C-cell

The C-cell has the most unusual geometry and presented the greatest challenge of all the cells to make characterization measurements of the radionuclides. General radiation shine from the pit and tunnel area contribute to the upper level flux/dose background.

3.2.5.1 C-cell Dust Samples

The dust samples from the C-cell are very high in both ^{90}Sr and ^{60}Co and only moderate in value for ^{137}Cs and ^{241}Am. The pit has evidence of having been flooded, since watermarks and residues cover the walls of the pit. Scrapings from the pit wall have very high ^{90}Sr, low ^{137}Cs and intermediate amounts of ^{60}Co and ^{241}Am.

3.2.5.2 In-place Measurements

In-place measurements of the floor and sump area with the MRAL-I show higher readings than in any of the other cells, except for the center of B-cell, where the ^{241}Am dominates. Measurements with the MRAL-II into the C-cell tanks indicated a majority of ^{60}Co, rather than the ^{137}Cs of the other cells. The ^{60}Co provides added background in the energy range of ^{137}Cs, making it more difficult to distinguish from the background radiation.

3.2.5.3 Smear Sample Data

Data from the flange smears followed the general trend of the other cells. There are moderate amounts of contamination in the first wet smears of the triple sequence. No flange had an excessive amount of activity. This indicates a minimum of gasket leakage.

3.2.5.4 Tunnel

Special attention was paid to the tunnel area. This region is a blind end and yet has some of the highest concentrations of radio-

nuclides in the dust. This is possibly due to large quantities of residual radionuclides in the piping. The pipes are more continuous inside the tunnel and not amenable to opening of flanges so no interior samples were taken. This is a higher dose area, and therefore of concern to worker exposures for D&D planning.

3.2.5.5 Pit Wall

One sample was scraped off of the pit wall in C-cell. The sample was taken at approximately chest height. The contamination layer in the pit area was approximated by this sample, assuming it is representative of a uniform distribution everywhere along the wall.

3.2.6 Non-TRU Measurements in C-cell

The highest non-TRU contamination in C-cell is also in the pit area and tunnel. Cobalt-60 is the dominant radionuclide here, where the B-plant material came into the cell. Appendix Table A.3.2 shows that both ^{60}Co and ^{90}Sr have their highest values here. Samples 236 and 237 (solids) show this. Nowhere else in the cells do the solids have this much non-TRU per gram. The remaining measurements are not unusual except for the in-place measurement #B24W12, taken over the sump. Here the cobalt-60 value also dominates the measurement.

3.2.7 TRU Measurements in F-cell

F-cell dust samples have the highest concentrations of TRU for all cells, but less total amount of dust covers floors and equipment. Many flanges had very low amounts of smearable contamination, but some still indicated small amounts of gasket leakage.

3.2.7.1 In-place Measurements

The MRAL-I measurements show moderate amounts of both ^{241}Am and ^{137}Cs. The measurement over the sump, #B24W15, shows greater than 2 nCi per square centimeter. This is the highest concentration of any location within the building. It suggests that the sumps may have been one source of the TRU in the cell dust.

3.2.7.2 F-10 Loadout Hood

Access into this hood was difficult. Only one measurement was attempted, that with the detector in the lowest part of the hood drain sump. The sump is approximately 6 inches square by 2 or 3 inches deep; the north wall extends upward behind the detector. Because of the odd geometry of the sump, detailed description of the measurement is not given here. Those desiring greater detail should look at the 224-B facility drawings.

In making the inventory estimates for the loadout hood, the ^{241}Am gamma rays were assumed to originate from an open, 6-inch sphere. This is about the size of the sump where the detector was placed.

Because of their greater energy the ^{137}Cs gamma rays were assumed to originate from an open sphere 36 inches in diameter, which is about the interior width of the loadout hood.

3.2.8 Non-TRU Measurements in F-cell

The same exclusions and general comments made for the TRU measurements apply to the non-TRU. Cobalt-60 is nearly absent from this cell, and there is wide variation even in the amounts of ^{137}Cs. Therefore, non-TRU ratios are not given for the smear samples, but only as measured for the dust.

3.3 MISCELLANEOUS MEASUREMENTS

The miscellaneous measurements are summarized in Table 3.2.

3.3.1 Ion Chamber Radiation Measurements

The ion chamber exposure rates (gamma and penetrating beta) are shown in Table 3.2 for various locations both inside and outside of the cells. Neutron dose rates were measured by the RPD and are tabulated in Appendix B, by cells. Exposure rates are nearly at background levels except in C-cell. The rate in C-cell pit and tunnel rises a factor of 6 times above the average value in clean areas, and over 4 times the cellular average, not including these two areas. All exposure/dose rates represent approximately 90% of the maximum display rate over a 2 to 5-minute period.

3.3.2 Air Samples

The air samples showed only ^{137}Cs at concentration above minimum detection limits. Of these, the air sample in A-cell stands out most conspicuously. The APDU believes that while this sample was being collected, the upper level doors to the cell were opened and closed. Larger than normal amounts of interior air were directed outward at the bottom entrance. This probably stirred up more of the floor dust and contributed to the higher sample activity.

3.3.3 Contributions to Dose/Exposure Rate.

A qualitative correlation may be made between the cobalt-60 in the C-cell, especially the pit and tunnel areas, and higher exposure rate readings from the Reuter-Stokes ion chamber. The in-place measurements show ^{60}Co is the primary radionuclide in the cell. Similarly, where the ^{60}Co is reduced, (e.g., F-cell) the ion chamber readings were correspondingly lower. The in-place measurements do not measure ^{90}Sr, but the scrapings from the pit wall indicate large amounts of this contaminant also. Therefore, higher exposure rates in C-cell are probably due to the larger amounts of ^{60}Co and ^{90}Sr in the tanks and in the pit wall residue.

The D-3 tank has been modeled by a cylindrical source of plutonium (weapons grade) whose strength was adjusted to match the measured neutron dose around it, see Appendix C. This was confirmed by the repeat measurements for D-3 tank, see Appendix D.

Table 3.2 224-B MISCELLANEOUS MEASUREMENTS

LOCATION	RESULT
Air Samples	^{137}Cs*
A-cell	75.3 E-12 uCi/milliliter
B-cell	4.9 E-12
C-cell	4.8 E-12
D-cell	<2.3 E-12
E-cell	<2.4 E-12
F-cell	3.1 E-12
MRAL-II In-place Measurement	
Building Air Intake	1.51 nCi total, ^{137}Cs*
Ion Chamber Readings	micro-R/hr **
A-cell	3 readings, between 10.2 - 11.5
B-cell	3 readings, between 10.0 - 11.8
	1 reading in center of cell, 13.3
C-cell	2 readings on main floor, less than 20
	2 readings in pit, less than 50
	1 reading in tunnel, 66***
D-cell	1 reading sector B-1, 15
	1 reading sector F-1, 18
(reconfirm)#	7 readings less than 25
E-cell	5 readings, all less than 12.9
F-cell	4 readings, all less than 18
	1 reading, 3 feet above sump, 24
1st floor, clean side	3 readings, all less than 11.4
2nd floor, clean side	6 readings, all less than 12.8
3rd floor, clean side	5 readings, all less than 12.8
[Outside the facility]	10 micro-R/hr**
Neutron Dose Reading	
D-cell, around D-3 tank	<0.1 mrem/hr, average of several

Notes:

* All other radionuclides were less than minimum detection level.

** Special effort was not taken to totally map the exposure rate readings; it is not appropriate to subtract a background from them. Probably 40-70% of the reading outside the facility truly represents "background" not produced by man.

*** Highest exposure rate area.

\# Details of the reconfirmation measurement are in Appendix D.

4.0 INVENTORY ANALYSIS AND CONCLUSIONS

The purpose of this chapter is to present a summary of the radiological environment in the 224-B hot cells. It is intended to provide estimates of inventory for the purpose of disposing of the tanks and other equipment as a part of the D&D activity for the facility.

- The estimated total TRU inventory is 37.7 (113 maximum) curies, including ^{241}Am and all isotopes of plutonium.
- The combined non-TRU inventory is 26.8 (80 maximum) curies of cobalt-60, cesium-137 and strontium-90.
- The D-3, F-8 & F-9 tanks contain the most radioactive material, over 80% of the estimated inventory.

4.1 METHOD

The building inventory was estimated in the following manner:

- Each of the several grouping categories was analyzed for averages and standard deviation of the four primary radionuclides (^{241}Am, ^{60}Co, ^{137}Cs and ^{90}Sr).
- The ^{241}Am inventory was found from averages of each cell's group categories.
- The plutonium-239 was estimated from those samples with enough activity to quantify both the ^{241}Am and ^{239}Pu gamma ray photopeaks by GEA. Averages of both were used to find the general ratio of $^{239}Pu/^{241}Am$ for final inventory estimates.

- The maximum estimates are given as 3 times the standard deviation above the average in the tables.

4.2 ESTIMATION OF A-CELL TRU INVENTORY

The following sections deal with the A-cell radionuclide characterization. For comparison purposes, the TRU results and non-TRU results are grouped together in tables 4.1 and 4.2, respectively.

4.2.1 Estimating the ^{241}Am in the Cellular Dust

The ^{241}Am per gram value was found by weight-averaging results of the dust samples. The average dust coverage was determined by comparing the in-place three-measurement average with the value after sweeping sector A-1 (measurement B24W04). This net value is 236 pCi/sq cm. The maximum value was nearly twice this average.

Then, a suitable check on the method had to be made. From the average value of ^{241}Am in the actual dust samples collected, the weight distribution of dust solids was found. This value is 0.4 g/sq cm (equivalent to a uniform thickness of 2.5 mm), which is a reasonable figure for the facility. The standard deviation (60%) among the in-place measurement results is smaller than that for the smear samples and dust solids. The APDU estimated a 75% weighted average for the entire facility.

TABLE 4.1 SUMMARY OF TRU INVENTORY

CELL	A	B	C	D	E	F
CATEGORY			Americium-241 (curies)			
Dust: Floor, Walls & Equip.	6.4E-4 (191%)*	4.6E-4 (77%)	4.3E-4 (106%)	1.6E-4 (247%)	8.1E-5 (131%)	8.4E-5 (169%)
Gutter/sump Samplers	2.2E-5 (103%)	2.2E-5 (103%)	3.8E-5 (103%)	2.2E-5 (103%)	2.2E-5 (103%)	4.4E-5 (103%)
Tanks,** Centrifuges	<4.1E-2 (96%)	<7.0E-2 (96%)	<1.8E-1 (96%)	3.5E+0# (86%)	<5.0E-2 (96%)	1.3E+0 (96%)
Piping	1.7E-2 (99%)	1.7E-2 (99%)	2.1E-2 (99%)	1.7E-2 (99%)	1.7E-2 (99%)	2.1E-2 (99%)
Miscellaneous	C-pit walls: 2.9E-4				Loadout hood:	6.8E-4
Totals	**<5.9E-2**	**<8.8E-2**	**2.0E-1**	**3.5E+0**	**6.7E-2**	**1.3E+0**

GRAND TOTAL - ^{241}Am 5.2 Ci (75%)*

GRAND TOTAL - ^{239}Pu 31.1 Ci [0.5 kg]##

TOTAL: All Pu isotopes 32.6 Ci (99%)

The GRAND TOTAL of both ^{241}Am and all plutonium is 37.8 curies. ###

Notes:

* The amount in parenthesis is the estimated standard deviation (SD) the sample (category) based on the measurement survey. One SD corresponds to a 68% level of confidence in accuracy of the value.

** The A-cell tanks did not have a positive net reading through the wall, therefore the average includes a minus error only. The same applies to all other tanks, which read "background" only.

\# The value for the D-cell is based on a second entry into the cell, reported by letter in the Appendix.

The $^{239}Pu/^{241}Am$ ratio [13.14:1] was used to find all Pu except that in D-3, which was a direct measurement of 7.4 Ci of ^{239}Pu.

###The maximum upper limit estimate (3-SD) of all TRU is 94 Ci.

TABLE 4.2 SUMMARY OF NON-TRU INVENTORY

CELL	A	B	C	D	E	F
CATEGORY			Cesium-137 (curies)			
Dust on floor, Walls & Equip.	1.9E-4	2.6E-4	3.6E-4	1.3E-4	6.8E-5	4.0E-5
Gutter, sump Samplers	6.4E-6	7.4E-6	2.2E-4	1.8E-5	1.9E-5	2.1E-5
Tanks, ** Centrifuges	<1.1E-2	<3.0E-3	2.6E-1	<1.0E-1#	3.8E-2	6.5E-1
Piping	4.9E-3	4.9E-3	6.1E-3	4.9E-3	4.9E-3	7.0E-3
			Miscellaneous			
					F-10 Loadout hood:	1.9E-8
C-pit walls:	(^{137}Cs @ 3.4E-5),(^{90}Sr @2.7E-3),(^{60}Co @1.4E-4)					
Air filter: 1.5E-9						
Totals (curies)						
^{137}Cs	1.6E-2	8.2E-3	2.7E-1	1.0E-1	4.3E-2	6.6E-1
^{90}Sr*	3.6E-2	6.0E-3	1.9E+1	1.2E+0	5.4E-2	1.3E+0
^{60}Co*	6.0E-3	3.0E-3	3.7E+0	1.4E-1	6.0E-3	<5.E-3

GRAND TOTAL, all non-TRU: 26.5 Ci (75%)** ##

Notes:

* ^{90}Sr and ^{60}Co values are estimates from the ratios established during the sample analysis, summarized in Table 3.1.

** The same standard deviation for the facility is assumed as for the TRU.

\# The value for the D-cell is based on both modeling estimates and in-place measurements for the D-3 tank.

The errors for the modeling are assumed to be equal to the rest of the measurements. The same SD is assumed as for the ^{241}Am. Therefore, the non-TRU maximum (3-SD) upper limit is 59 Ci.

o ^{241}Am Estimate in the Floor Dust

The unused floor area is estimated at 50 square meters, based on the facility sketches. The dust load is therefore 118 microcuries of ^{241}Am for the floor.

o ^{241}Am Estimate for Dust on Walls

The walls are assumed to have a linear gradient distribution of dust with the highest concentration at the bottom, zero at the top. The same concentration is assumed at the base of the walls, as for the floor average. The wall area is estimated at 240 square meters, including the gallery walkway. The ^{241}Am dust load for the walls is estimated at 281 microcuries of ^{241}Am.

o ^{241}Am in Equipment Dust

The equipment (including piping, but excluding the piping flanges) is included in this category, with an estimated approximate surface area of 100 square meters. The ^{241}Am dust load on the equipment exteriors is estimated at 236 microcuries of ^{241}Am.

o Total ^{241}Am Estimate in Cell Dust

The total contribution of the dust load to the A-cell inventory of ^{241}Am is 635 microcuries.

4.2.2 Method of estimating tank inventory

The tank inventory is based on four measurement data sets:

1. MRAL-II in-place measurements,
2. Internal scrapings and smears, and
3. External flange smears.
4. Neutron dose rate (D-3 tank, only)

First, these were used to estimate the non-TRU surface density inside the tank, followed by conversion to the ^{241}Am total. The $^{239}Pu/^{241}Am$ ratio was then used to estimate the fissile content and a final TRU tank inventory.

o Non-TRU Estimate

The MRAL-II through-the-wall measurements with the side-looking detector were used to estimate a concentration of either ^{137}Cs or ^{60}Co on the first inside tank wall. This calculation ignores radioactivity on the farther wall of the tank, due to the distance and the inverse-square law of gamma radiation dispersion.

o Estimate of ^{241}Am

The ratio of ^{241}Am to the non-TRU component was determined from scrapings inside flanges opened during the survey. If no scrapings existed for the tank, then the general average for the cell was used, adjusted by the ratio found on flange smears for the cell. Subjective judgement had to be used in some cases in the selection

of an appropriate set of ratios for a particular cell, particularly when the data set was small or exhibited a large standard deviation.

o Estimating ^{239}Pu

The ^{239}Pu to ^{241}Am ratio was determined as an average for the entire facility based on several interior scrapings and smear samples which had the largest amounts of ^{241}Am by GEA. Again, this selection process was somewhat subjective. The larger values of ^{241}Am were selected; so that errors in the $^{239}Pu/^{241}Am$ ratio would be minimized. The facility average was 13.14:1 based on samples 118, 222, and 342 in A, B and F-cells.

o Total TRU Estimate

Quantities by weight of TRU were converted from the curie activity levels according to the laws of radioactive decay, with an assumed ^{239}Pu/total-Pu fraction of 95%. This is consistent with production grades at Hanford. If the material processed in 224-B was of a different ^{239}Pu fraction, then the total TRU inventory would change, but the total fissile part (^{239}Pu, essentially) remains unchanged.

4.2.3 Other ^{241}Am Calculations

The other categories shown in the summary provide far smaller input to the inventory. The general steps used were as follows:

o Piping

The piping inventory was determined as an average for the entire facility. This was because pipes that begin in one cell often go to another, such that the processed material was averaged as residue along the entire length of the pipe. Scrapings and smears from inside the piping flanges were used to estimate a surface density per foot. A value of 400 linear feet of 3-inch piping was assumed for the cells. Even if this length were increased to 1000 feet (factor of 2.5 increase), the inventory would be effected very little because the majority of the radionuclides are in the tanks.

o Gutters, Sumps and Samplers

A linear smearable density was determined by averaging the smear samples. This value was multiplied by an assumed average gutter length of 25 feet per cell, except in F-cell, which was assumed to be 50% longer. The MRAL-I downlooking measurements in C and F cells were used to determine the sump inventory, as an average for the entire building. The sampling boxes were estimated by using the gutter smear data and the area of a sump.

o Other Cell Calculations

The inventory calculations for Cells B-F proceeded in the same manner as those in A-cell. Results are shown in Table 4.1 for the ^{241}Am component.

4.2.4 C-cell Pit Walls

The C-cell pit has noticeable residues and watermarks from being flooded. The MRAL-II measurement into the C-9 tank showed that the primary radionuclide in this area is ^{60}Co. It was not appropriate to extend the in-place tank analysis for the MRAL-II detector to the pit walls, but APDU did make an inventory estimate based on the pit wall scrapings combined with several assumptions.

o Wall Residue Inventory Estimate

The wall residue was scraped from approximately a 25 square centimeter (2"x2") area. This was assumed to represent half of the contamination on the wall. The remainder was assumed to have penetrated farther into the concrete. The floor of the pit has already been included in the C-cell inventory using the MRAL-I in-place measurements. The walls were assumed to have a uniform distribution of activity, characterized by the scraping sample.

4.2.5 Adequacy of Smear Sample Data

It was mentioned in Section 2.5 that GEA of the dry floor smears was eliminated to a great degree beginning with sample 20. To test the veracity of this decision, a linear correlation was made of the ratio of ^{241}Am to ^{137}Cs in A-cell for both the wet and dry smears. In figure 4.2 smear sample data are plotted with total ^{241}Am on the Y-axis and total ^{137}Cs on the X-axis. A log-linear fit is made to both wet and dry samples. The slopes of the

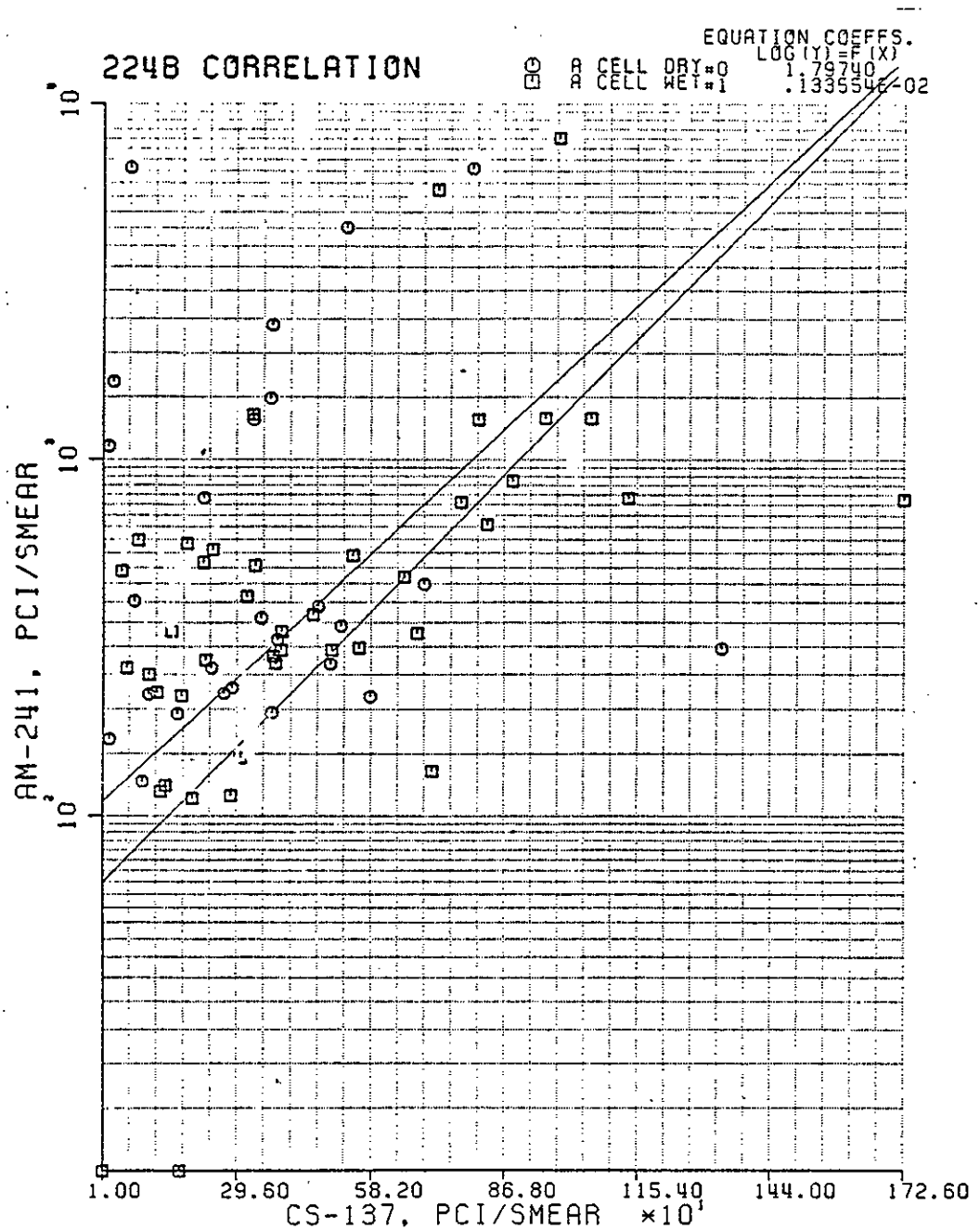

Figure 4.2 Correlation of ^{241}Am and ^{137}Cs in A-cell wet and dry smears.

two lines are indicative of the ratio of ^{241}Am to ^{137}Cs. No extreme differences in the slopes are observed, beyond normal data scatter. Because of this, the APDU decided to only analyze the wet smears during the majority of the sampling.

4.3 TANK INVENTORY

Table 4.3 presents the ^{241}Am estimates for the individual tanks. Where no direct measurement into a tank with the MRAL-II side-looking detector was able to quantify the inside radionuclides, a "less-than" value was calculated based on the D-4 tank result. The D-4 tank was measured from the inside and gave a finite value, but was not distinguishable from background on the outside.

The curie levels of plutonium may be converted to mass by the relation: 1 Curie (Plutonium-239) = 16.1 grams.

o D-3 Tank Result

The D-3 tank in-place measurement was considered an outlier, so alternate methods were used to estimate an inventory in this tank. The Radiation Protection Engineering group modeled the dose rates for both neutron and gamma from a sheet cylinder of plutonium and cesium-137 inside the tank and extrapolated this result to the Snoopy and ion chanber measurements in the D-cell. Repeat in-place measurements verified the estimates. This reduced the D-3 tank estimate to 3.4 Ci of ^{241}Am plus 7.4 Ci of plutonium.

TABLE 4.3 SUMMARY OF IN-TANK INVENTORY ESTIMATES

	^{241}Am (total Ci) ##				
A-CELL	A-1	A-3	A-4	Centrifuge	
	<.003**	<.003	<.001	0.034*	
B-CELL	B-1	B-3	B-4	B-6	Centrifuge
	<.012	<.012	<.006	<.006	0.034*
C-CELL	C-4	C-7	C-8	C-9	
	<.029	0.038	<.083	<.029	
D-CELL	D-1	D-3	D-4	Centrifuge	
	<.028	3.44#	<.010	0.034*	
E-CELL	E-1	E-3	E-4	Centrifuge	
	<.001	<.001	0.014	0.034(284%)***	
F-CELL	F-1	F-7	F-8	F-9	
	<.061	0.061	0.608	0.468	
	F-2 Cent	F-22 Cent		2 Small Centrifuges	
	0.034*	0.034*		0.03 (total)	

Notes:

* The centrifuges were inaccessible with the MRAL-II detector. Value is based on the E-cell measurement, as typical of all.

** Where no cesium-137 measurement was possible for the side-looking detector into the tank, a "less than value" is given based on the D-4 interior measurement, the equivalent E-4 profile, and modified by the Am/Cs ratio in that cell.

*** The value in parentheses is that of one standard deviation relative to the single measurement value.

\# This a revised value based on a second entry into the D-cell on May 16, 1985. It reduces the inventory estimate by approximately a factor of 50, compared to an earlier estimate.

The ^{239}Pu inventory of each tank can be estimated by multiplying the ^{241}Am estimate by 13.14, except for the D-3 tank. A direct measurement of the D-3 tank gave 7.4 Ci of ^{239}Pu.

4.4 NON-TRU CALCULATIONS

The calculations for cesium-137 are summarized in Table 4.2 for each of the cells and the several general categories. The results are based on the averages in Table 3.2 and the same area or volume estimates made for the ^{241}Am calculations. The ratios of $^{90}Sr/^{137}Cs$ and $^{60}Co/^{137}Cs$ are based on the dust and smear samples taken in each cell. The total non-TRU inventory is based on the ^{137}Cs result multiplied by these ratios.

4.5 ERRORS

4.5.1 Sources of Error in the Tank Estimates

In the analysis the intention has been to err on the high side of the estimate in order to provide a suitable margin of safety in planning. There are two major and one smaller contributions of error in the method:

- The non-TRU in the large tanks is estimated from a low intensity reading taken horizontally into the side of the tank. Uncertainties associated with this measurement are smaller than the remaining two estimation steps.
- The first major source of error lies in the estimation of ^{241}Am based on the ratio of ^{241}Am to ^{137}Cs. The ^{241}Am estimate must be based on smear samples where no scrapings were made.
- Finally, the ^{239}Pu component of the TRU is also estimated based upon the already estimated ^{241}Am. These two estimates span six orders of magnitude from microcuries per square

centimeter to as much as curies for the volume of the tank. Small uncertainties are greatly multiplied. This is exemplified by the difference in the RPE estimate vs the MRAL-II in-place result for the D-3 tank.

4.5.1.1 **Individual Tank vs Facility Values -- A Caveat**

The errors associated with assigning a definite inventory to each tank are greater than that of assigning a total TRU inventory to the entire class of tanks. Averaging the individual measurements, builds added confidence in the result. The variance is reduced in proportion to the square root of the total number of measurements made. If only one measurement is made, the confidence is less. A facility-wide standard deviation estimate of 75% was made after the above analyses were completed. The maximum limits (Table 4.1 and 4.2 footnotes) represent three standard deviations above the inventory estimate which is based on the averages.

4.5.2 Other Inventory Estimates

o Strontium-90 Uncertainties

Because of the nonstandard geometry of the wadded smear material, the ^{90}Sr smear sample values can only be considered a general guide to relative amounts of this radionuclide. The APDU measured each sample twice, from each side, and averaged the results. The phoswich detector response was compared to both a uniform sand source and a flat filter paper source in developing the sensitivity.

The phoswich detector has shown the potential for providing rapid analyses in both laboratory and field applications. Response, attenuation factors, and spectral interferences have not been completely characterized. This deficiency limits the realization of its full potential by inhibiting evaluation of collected data. These measurements could be biased low by an estimated 20%, this would cause the ^{90}Sr:^{137}Cs ratio to be low. Thus the total non-TRU inventory could be low. Additional characterization of the phoswich system is planned. If appropriate, a letter correcting the values will be issued in the future by APDU.

4.6 CONCLUSIONS

During the general survey, and later detailed characterization measurements, the scope of investigation was modified to assure adequacy of data and maximum usefulness of the results. After analysis of the samples and making the inventory calculations, the APDU offers the following conclusions:

- Nearly all of the tanks have inventories of less than 1 curie of TRU. Because of extrapolation errors the tanks with the larger inventories are suspect as possible "fliers." Only a sampling program with extensive interior measurements can establish the veracity of these estimates. Error estimates at the 99% confidence level are used to estimate the greatest maximum probable value for the tanks with "less than" amounts.

- The dust in the building contains considerable inventory of both TRU and fission products. Respiratory protection will be needed for D&D workers.

- Most flanges have a considerable amount of contamination which has leaked past the gaskets.

- The errors for the in-tank inventory may seem greater than desired. To improve this, APDU made measurements directly within the D-4 and E-4 tanks using the MRAL-II and detector. Tank D-3 was remeasured extensively to remove ambiguity in its inventory value, see Appendix D. Tanks D-3, F-7, F-8 and F-9 plus the centrifuges should be treated individually during D&D, opening covers and remeasuring interior residue.

- The inventory in the C-cell pit is predicated on assumptions concerning the wall scrapings and extending this information to the entire wall area. It is quite likely that the deposition of material is not uniform with location. It is also quite likely that the contamination penetrates the walls in an uneven pattern. This would quite likely require a large number of core samples with which to document the exact nature of the problem. However, the impact of the pit residue is small, and so this point is moot.

- Comparisons based on only the smear samples may not necessarily represent absolutes, but only variations in the amount of scrubbing involved in the taking of the sample. Therefore, in the inventory estimates, the APDU has tried to use nonsmear data in preference to smear sample data. However, the smear samples have been very useful in developing ratios of radionuclides.

- The source of the contamination in the dust is believed to have been evaporation from the gutters and sumps, assisted by general air currents from the ventilation system and overhead openings. The building is far from airtight, as evidenced by the large amount of sand and debris on the floor.

ACKNOWLEDGEMENT

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APPENDICES

A. SAMPLE IDENTIFICATION AND LOCATIONS IN 224-B

TABLE A.1.1 A-CELL MEASUREMENTS - TRU (Page 1 OF 5)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{241}Am pCi*
Floor Smear samples			
1	A-1 grid sector (1) smear	wet	776
2		dry	262
3	A-2 grid sector smear	wet	283
4		dry	344
5	A-3 grid sector smear	wet	275
6		dry	448
7	A-4 grid sector smear	wet	784
8		dry	125
9	A-5 grid sector smear	wet	223
10		dry	220
11	A-6 grid sector smear	wet	874
12		dry	315
13	B-1 grid sector smear	wet	294
14		dry	222
15	B-4 grid sector smear	wet	517
16		dry	389
17	B-5 grid sector smear	wet	370
18		dry	268
19	B-6 grid sector smear	wet	506
21	C-1 grid sector smear	wet (2)	332
23	C-2 grid sector smear	wet	760
25	C-3 grid sector smear	wet	659
27	C-4 grid sector smear	wet	471
29	C-5 grid sector smear	wet	328
31	C-6 grid sector smear	wet	1310
74	D-1 grid sector smear	wet	415
77	D-2 grid sector smear	wet	584
73	D-3 grid sector smear	wet	122
69	D-4 grid sector smear	wet	<mdl
67	D-5 grid sector smear	wet	179
85	D-6 grid sector smear	wet	219

Notes:
* Values given are total per smear, except as noted.
(1) Refer to text for description of grid numbering system.
(2) Beginning with #21, primarily only the wet samples were analyzed.

TABLE A.1.1 (CONTINUED, Page 2 of 5)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{241}Am pCi
76	E-1 grid sector smear	wet	112
82	E-2 grid sector smear	wet	262
327	E-3 grid sector smear	wet	271
329	E-4 grid sector smear	wet	152
83	E-4 grid sector smear	dry	217
87	E-5 grid sector smear	wet	298
106	E-6 grid sector smear	wet	596
330	F-1 grid sector smear	wet	320
326	F-5 grid sector smear	wet	2750 (+)
86	F-6 grid sector smear	wet	1310
108	F-6 grid sector smear	wet	269
	AVERAGE: Wet floor smears (32 total)		519 (99%)**
	AVERAGE: Dry floor smears (10 total)		281 (34%)
	GENERAL AVERAGE:		**475 pCi/smear**
Gutter samples			
93	G-1 wall/floor joint	wet	331
94	G-2 wall/floor joint	dry	485
109	G-3 wall/floor joint	dry	2410
90	G-4 wall/floor joint	dry	1090
40	G-5 wall/floor joint	dry	1660
89	G-6 wall/floor joint	dry	783
104	G-3 sector gutter	dry	1490
91	G-5 sector gutter	dry	6610
92	G-6 sector gutter	dry	4510
100	G-2 grid sector smear (typ)	wet	489
105	G-3 grid sector smear (typ)	wet	1340
101	G-4 grid sector smear (typ)	wet	251
110	G-5 grid sector smear	wet	8040
103	G-6 grid sector smear (typ)	wet	5760
	AVERAGE: Gutter, all smears		**2518 (103%)**

Notes:
(+) Indicates significant or highest value in a category.
** Value in parenthesis is 1 standard deviation (SD) for the sample category, this notation applies to entire table series.

TABLE A.1.1 (CONTINUED, Page 3 of 5)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{241}Am pCi	
44	2nd floor, vestibule smear	dry	362	
78	Op deck, wall smear	wet	540	
318	2nd floor, A-1 sector	wet	134	
320	2nd floor, A-2 sector	wet	562	
319	2nd floor, A-3 sector	wet	117	
59	2nd floor, A-4 sector	wet	218	
66	2nd floor, B-1 sector	wet	114	
321	2nd floor, B-2 sector	wet	1090	
317	2nd floor, B-4 sector	wet	1300	
314	2nd floor, C-1 sector	wet	294	
62	2nd floor, C-1 sector	dry	297	
322	2nd floor, C-2 sector	wet	171	
316	2nd floor, C-4 sector	wet	146	
61	2nd floor, C-4 sector	dry	194	
	AVERAGE: All 2nd level smears		**396 (94%)**	
Tank and Equipment samples				
41	A-1 Tank, motor vent smear	wet	265	
48	A-1 Tank riser flange @3:00	wet	244 (3)	
49	A-1 Tank riser flange @2:00	wet	169	
102	A-1 Tank header flange @1:30	wet	31900	
241	A-1 Tank, side flange	dry	34400 (+)	inside pipe
52	A-1 Tank, motor sides	wet	1020	
53	A-3 Tank typical flange	wet	328	
54	A-3 Tank motor mounting ring	dry	1300	
42	A-3 Tank, cover	wet	1510	
39	A-3 Tank Flange @8:00	wet	599	
43	A-3 Tank flange @8:00	dry	1400	
45	A-3 Tank riser flange @2:00	dry	165	
46	A-3 Tank (typ) side smear	wet	<mdl (4)	
95	A-4 Tank, SE cover flange	dry	267	
97	A-4 Tank, riser flange (typ)	dry	<mdl	
107	A-4 Tank, side flange (typ)	dry	<mdl	
242	A-4 Tank, side flange	wet	14500	Second inside.

Notes:
(3) Tank flangwes are referenced to a clock, with north = 12:00.
(4) Ten smear samples were taken, none exceeding normal background.

TABLE A.1.1 (CONTINUED, Page 4 of 5)

SAMPLE	LOCATION/DESCRIPTION	WEIGHT	^{241}Am pCi/g	
55	A-centfuge inlet flge @5:00	dry	400	
57	A-centfuge inlet flge @12:00	dry	<mdl	
58	A-centfuge inlet flge @1:00	dry	<mdl	
60	A-centfuge frame, westside	dry	<mdl	
63	A-centfuge drain flange	dry	402	
64	A-centfuge inlet flge @6:00	dry	<mdl	
65	A-centfuge, east side smear	dry	230	
72	A-centfuge, motor shaft	dry	6640	Greasy shaft
313	Centfuge, west side A-frame	wet	766	
315	Centfuge, east side A-frame	wet	<mdl	
323	Centrifuge, sides	wet	67	
331	Centfuge top pipe & Collector	wet	384	
	AVERAGE: Tank and piping flanges		**2267 (349%)**	
	AVERAGE: Equipment exteriors		**1072 (180%)**	
328	Vestibule, sampler-A	wet	160	
325	Vestibule, sampler-C	wet	<mdl	
324	Vestibule, sampler-D	wet	122	
	AVERAGE: Sampler smears		**94 (89%)**	
Solids				
33	Pigeon feces and dust	13.0g	160/g (5)	
34	Floor dust sample #1	16.1g	75/g	
35	Floor dust sample #2	40.9g	3290/g (+)	
36	Floor dust sample #3	57.8g	127/g	
37	Floor dust sample #4	46.2g	408/g	
38	Floor dust sample #5	51.7g	381/g	
119	Gallery walkway, dust #1	19.0g	184/g	
120	Gallery walkway, dust #2	11.5g	230/g	
	WEIGHTED AVERAGE: All dust samples		**741 pCi/g**	
118	A-3 Tank, flange @4:00,inside	2.6g	42400/g (+)	Scrapings
121	A-1 Tank, side flange @3:00	3.9g	735/g	Inside pipe
	AVERAGE: Inside pipe scrapings		**17401 pCi/g**	

Notes:
(5) No effort made to separate the dust from pigeon feces

TABLE A.1.1 (CONTINUED, Page 5 of 5)

MRAL-I In-place measurements

MEASUREMENT(6)	LOCATION	TYPE	^{241}Am
B24W01	Grid sector G-3	(7)	392 pCi/sqcm
B24W02	Grid sector G-6		210
B24W03	Grid sector G-5		119
		AVERAGE:	240 pCi/sqcm
B24W04	Grid sector A-1	(8)	4
	NET FLOOR AVERAGE:		**236 pCi/sqcm**

Notes:
(6) This is the MRAL-I storage identification sequence for the GEA spectrum.
(7) Using a downlooking detector, 6 inches above floor, within a shield that views a 14-inch diameter circle on the floor.
(8) This area was swept, before the measurement.

TABLE A.1.2 A-CELL MEASUREMENTS - NON TRU (Page 1 of 4)

SAMPLE	LOCATION/DESCRIPTION		^{90}SrpCi	^{137}CspCi	^{60}CopCi*	
Floor Smear samples						
1	A-1 floor sector smear	wet	213	1726	343	
2		dry	37	242	76	
3	A-2 floor sector smear	wet	30.3	373	100	
4		dry	89	517	60	
5	A-3 floor sector smear	wet	97.6	229	140	
6		dry	77	696	174	
7	A-4 floor sector smear	wet	121	1136	205	
8		dry	20	96	34.5	
9	A-5 floor sector smear	wet	<mdl	126	2.5??	(1)
10		dry	87	109	5.5??	
11	A-6 floor sector smear	wet	6.7!?	886	70	
12		dry	27	382	40	
13	B-1 floor sector smear	wet	101	389	125	
14		dry	178	269	40	
15	B-4 floor sector smear	wet	77	225	39	
16		dry	<mdl	469	85	
17	B-5 floor sector smear	wet	17?	458	112	
18		dry	<mdl	495	111	
19	B-6 floor sector smear	wet	23	334	90	
21	C-1 floor sector smear	wet	54	390	38	
23	C-2 floor sector smear	wet	<mdl	775	63	
25	C-3 floor sector smear	wet	84	831	144	
27	C-4 floor sector smear	wet	84	654	145	
29	C-5 floor sector smear	wet	87	681	107	
31	C-6 floor sector smear	wet	292	1056	214	
74	D-1 floor sector smear	wet	87	318	35	
77	D-2 floor sector smear	wet	74	189	<mdl	
73	D-3 floor sector smear	wet	<mdl	145	18.5?	
69	D-4 floor sector smear	wet	87	174	36	
67	D-5 floor sector smear	wet	61	352	28	
85	D-6 floor sector smear	wet	<mdl	138	12.5!?	

Notes:
* For general explanatory comments see Table A.1.1
(1) Symbol key:
?? = less than 1 standard deviation (SD) above background.
!? = between 1 and 2 SD above background.
? = between 2 and 3 SD above background.

TABLE A.1.2 (CONTINUED, Page 2 of 4)

SAMPLE	LOCATION/DESCRIPTION		^{90}SrpCi	^{137}CspCi	^{60}CopCi
76	E-1 floor sector smear	wet	77	202	15.5?
82	E-2 floor sector smear	wet	<mdl	62	10.5!?
84	E-2 floor sector smear	dry	<mdl	--	--
327	E-3 floor sector smear	wet	153	280	181
83	E-4 floor sector smear	dry	--	581	107
329	E-4 floor sector smear	wet	<mdl	327	22?
87	E-5 floor sector smear	wet	111	556	125
106	E-6 floor sector smear	wet	57	86	9.5!?
330	F-1 floor sector smear	wet	53	249	31
326	F-5 floor sector smear	wet	241	359	50
86	F-6 floor sector smear	wet	57	956	69
108	F-6 floor sector smear	wet	17	377	70
	AVERAGE: Wet floor smears		71.6(99%)	473(80%)	84.6(90%)
	AVERAGE: Dry floor smears		57.2(100%)	386(52%)	73.3(66%)
	GENERAL AVERAGE:		**68.5pCi**	**452.3pCi**	**81.8pCi**
Gutter samples					
93	G-1 wall/floor joint	wet	34	156	32.5
94	G-2 wall/floor joint	dry	81	175	16?
109	G-3 wall/floor joint	dry	67	370	19.5?
90	G-4 wall/floor joint	dry	37	23?	29
40	G-5 wall/floor joint	dry	40	33	33
89	G-6 wall/floor joint	dry	84	226	74
104	G-3 sector gutter	dry	222	367	64
91	G-5 sector gutter	dry	202	799	37
92	G-6 sector gutter	dry	54	529	105
100	G-2 floor sector smear	wet	124	50	<mdl
105	G-3 floor sector smear	wet	60.5	330	5.5??
101	G-4 floor sector smear	wet	74	109	26.5
110	G-5 floor sector smear	wet	215	986	107
103	G-6 floor sector smear	wet	155	725	140
	AVERAGE: All gutter smears		**103.5pCi**	**384.4pCi**	**49.2pCi**
2nd level samples					
44	Op Deck vestbule floor	dry	94	347	118
78	Op deck,wall smear	wet	140	544	176
318	2nd floor, A-1 sector	wet	126	714	66
320	2nd floor, A-2 sector	wet	39	244	13.5!?
319	2nd floor, A-3 sector	wet	96	135	19.5?
59	2nd floor, A-4 sector	wet	111	177	6.5??

TABLE A.1.2 (CONTINUED, Page 3 of 4)

SAMPLE	LOCATION/DESCRIPTION		^{90}SrpCi	^{137}CspCi	^{60}CopCi
66	2nd floor, B-1 sector	wet	98	285	71
56	2nd floor, B-1 sector	dry	211	370	67
321	2nd floor, B-2 sector	wet	39	675	71
317	2nd floor, B-4 sector	wet	258	812	77
314	2nd floor, C-1 sector	wet	218	497	96
62	2nd floor, C-1 sector	dry	222	1336	129
322	2nd floor, C-2 sector	wet	123	385	47
316	2nd floor, C-4 sector	wet	144	304	9.5!?
61	2nd floor, C-4 sector	wet	111	169	83
	AVERAGE: All 2nd level smears		**129.4pCi**	**464.1pCi**	**68.1pCi**
Tank and Equipment samples					
41	A-1 Tank, motor vent	wet	27	<mdl	7.5!?
52	A-1 Tank, motor sides	wet	13	52	<mdl
48	A-1 Tk riser flge @3:00	wet	<mdl	56	<mdl
49	A-1 Tk riser flge @2:00	wet	<mdl	<mdl	<mdl
102	A-1 Tank header @1:30	wet	121	97	<mdl
241	A-1 Tank, side flange	dry	107	<mdl	<mdl
53	A-3 Tank flange (typ)	wet	51	<mdl	23
54	A-3 Tank motor mounting	dry	43.7	332	93
42	A-3 Tank, cover	wet	710	300	55
39	A-3 Tank Flange @8:00	wet	3.4??	10!?	<mdl
43	A-3 Tank flange @8:00	dry	47	<mdl	2.5??
45	A-3 Tk riser flge @2:00	dry	111	25	33
46	A-3 Tank sides	wet	<mdl	<mdl	4.5??
95	A-4 Tk, SE cover flge	dry	<mdl	370	32.5
97	A-4 Tk, typ riser flge	dry	<mdl	152	3.5
107	A-4 Tank, side flange	dry	13	<mdl	<mdl
242	A-4 Tank, side flange	wet	1296	161	<mdl
55	A-Cent inlet flge @5:00	dry	255	<mdl	1.5??
57	A-Cent inlet flge @12:00	dry	<mdl	8??	<mdl
58	A-Cent inlet flge @1:00	dry	<mdl	<mdl	24.5
60	A-Cent west frame	dry	17	1106	30
63	A-Cent drain flange	dry	128	77	3.5??
64	A-Cent inlet flge @6:00	dry	<mdl	<mdl	<mdl
65	A-centfuge, east side	dry	7!?	286	<mdl
72	A-centfuge,motor shaft	dry	1736	68	14.5?
313	A-Cent, west A-frame	wet	22	346	11.5!?
315	A-Cent, east A-frame	wet	<mdl	<mdl	<mdl
323	Centrifuge, sides	wet	22	<mdl	<mdl
	AVERAGES: All flanges		**128(235%)**	**56(169%)**	**29.7(310%)**

TABLE A.1.1 (CONTINUED, Page 4 of 4)

SAMPLE	LOCATION/DESCRIPTION		^{90}SrpCi	^{137}CspCi	^{60}CopCi
324	Vestibule, sampler-D	wet	61	57	18.5?
325	Vestibule, sampler-C	wet	74	322	5.5??
328	Vestibule, sampler-A	wet	136	229	2.5??
331	A-Cent Top pipe/colltr	wet	43	168	48
Solids		weight			
33	Pigeon feces and dust	13.0g	82/g	29.7/g	3.5/g
34	Floor dust sample #1	16.1g	69/g	62.5/g	<mdl
35	Floor dust sample #2	40.9g	570/g	357/g	66.8/g
36	Floor dust sample #3	57.8g	80/g	82.9/g	12.2/g
37	Floor dust sample #4	46.2g	277/g	348/g	91/g
38	Floor dust sample #5	51.7g	203/g	288/g	43/g
119	Gallery walk, dust #1	19.0g	157/g	150/g	52/g
120	Gallery walk, dust #2	11.5g	20.2/g	46/g	18/g
WEIGHTED AVERAGE: Dust samples			**221/g(113%)**	**215/g(107%)**	**55/g(86%)**
118	A-3 Tk flge @4:00	2.6g	3062/g	350/g	<mdl Scrapings
121	A-1 Tk, side flge @3:00	3.9g	1306/g	728/g	250/g Inside
AVERAGE: Inside pipe scrapings			**2008/g**	**577/g**	**150/g**

MRAL-I In-place measurements (2)

MEASUREMENT	LOCATION		^{137}Cs	^{60}Co
B24W01	Floor sector G-3		19 pCi/sqcm	2 pCi/sqcm
B24W02	Floor sector G-6		12	3
B24W03	Floor sector G-5		14	3
	AVERAGE:		15	2.67
B24W04	Floor sector A-1	(3)	9	3
NET FLOOR DUST AVERAGE:			**4 pCi/sqcm**	**-0-**

Notes:
(2) Using a downlooking detector, 6 inches above the floor, inside a shield that views a 14 inch diameter circle on the floor.
(3) This area was swept first before the measurement.

TABLE A.2.1 B-CELL MEASUREMENTS - TRU

SAMPLE	LOCATION/DESCRIPTION	TYPE	Am241 pCi*
Solids			
233	A-1 sector, dust sample	45.6g	199/g
231	A-8 sector, dust sample	44.1g	354/g
232	G-1 sector, dust sample	41.2g	792/g
230	G-6 sector, dust sample	45.0g	913/g (+)
229	Op deck,C-4 sector, P-feces	23.5g	9/g (1)
234	2nd floor vestble,sector C-1	32.9g	570/g
WEIGHTED AVERAGE:			**505.2/g**
Smear samples			
283	B-6 Tank, riser flange @9:30	wet	311 (2)
284	2nd floor, Cent drain flange	wet	694
285	B-4 Tank, side flange @3:00	wet	2620
286	B-4 Tank, side flange @4:00	wet	5630
287	B-1 Tank, side flange @1:00	wet	9000 (+)
288	B-3 Tank, side flange @3:00	wet	270
289	B-1 Tank, riser flange @7:30	wet	<mdl
290	2nd floor,C-3 sector smear	wet	1330
291	Op deck, sampler-B, flange	wet	2060
292	B-3 Tank, riser flange @12:30	wet	422
293	B-6 Tank, riser flange @1:00	wet	530

MRAL-I In-place measurements		^{241}Am	^{239}Pu (3)
B24W05	A-6 Floor sector	50 pCi/sqcm	1200 pCi/sqcm
B24W06	D-4 Floor sector	1681	11740
B24W07	G-6 Floor sector	92	8536
B24W08	D-4 Repeat w/o cone	8054	78100 (4)

Notes:

* See Table 3.A.1 for general explanatory notes.

(1) Since the access for pigeons has been cut off, no effort was made to separate the contamination in the dust from the feces.

(2) These are the first wet smears in a triple-smear sequence.

(3) The usual measurement is made with the detector 6 inches over the floor collimated to view a 14-inch diameter circle.

(4) This measurement is one inch off the floor unshielded to obtain the estimate of overall shine in the cell.

TABLE A.2.2 B-CELL MEASUREMENTS - NON TRU

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{90}SrpCi	^{137}CspCi	^{60}CopCi*
Solids					
229	Op deck C-4 sctr P-feces 23.5g		73.8/g	4/g	16/g
230	G-6 sector, dust sample 45.0g		347/g	148/g	124/g
231	A-8 sector, dust sample 44.1g		156/g	390/g	143/g
232	G-1 sector, dust sample 41.2g		173/g	193/g	53/g
233	A-1 sector, dust sample 45.6g		288/g	314/g	199/g
234	2nd floor, sector C-1 32.9g		655/g	770/g	308/g
	AVERAGES:		**284(65%)**	**308(75%)**	**145(68%)**
Smear samples					
283	B-6 Tank riser flge @9:30	wet	<mdl	<mdl	<mdl
284	2nd floor Cent drain flge	wet	65	23?(1)	<mdl
285	B-4 Tank side flge @3:00	wet	231	<mdl	25.5
286	B-4 Tank side flge @4:00	wet	43	<mdl	<mdl
287	B-1 Tank side flge @1:00	wet	158	<mdl	<mdl
288	B-3 Tank side flge @3:00	wet	<mdl	<mdl	<mdl
289	B-1 Tank riser flge @7:30	wet	<mdl	3??	10.5!?
290	2nd floor C-3 sector	wet	<mdl	<mdl	13.5!?
291	Op deck, sampler-B, flge	wet	<mdl	<mdl	<mdl
292	B-3 Tnk riser flge @12:30	wet	<mdl	<mdl	<mdl
293	B-6 Tank riser flge @1:00	wet	66	<mdl	28
MRAL-I In-place measurements			^{137}Cs		Co-670
B24W05	A-6 Floor sector	(1)	11pCi/sqcm		8pCi/sqcm
B24W06	D-6 Floor sector		20		3
B24W07	G-6 Floor sector		13		5
B24W08	D-4 repeat w/o cone	(2)	74		9

Notes:

* See Table A.1.1 for general explanatory comments.

(1) The measurement is made with detector 6 inches above the floor, viewing a 14-inch diameter circle within a collimation cone.

(2) This measurement made with detector unshielded, to estimate the overall shine in the cell.

TABLE A.3.1 C-CELL MEASUREMENTS - TRU

SAMPLE	LOCATION	TYPE	^{241}Am pCi*	
Solids				
235	A-1 sector, dust sample	29.2g	200/g	
236	A-6 sector, dust sample	40.1g	244/g	
237	D-3 gutter, dust sample	31.1g	832/g	
238	Tunnel floor, dust	22.7g	1910/g	
239	G-1 sector, dust sample	46.2g	124/g	
240	G-6 sector, dust sample	25.3g	50/g	
	AVERAGE: Dust solids		**472/g(106%)**	
Scraping samples				
224	C-7 Tank bottom flange	32.0g	12/g	Inside flange
225	C-4 Tank, outside wall	46.5g	13/g	
226	C-4 Tank bottom flange	26.7g	18/g	Inside flange
227	Pit East wall scrapings	16.2g	505/g	(1)
228	C-7 Tank, outside wall	42.4g	2.9/g	
	AVERAGE: Scrapings		**59.7/g(178%)**	
Smear samples				
249	C-4 Tk, riser flge @8:30	wet	308	
250	C-4 Tk, riser flge @8:30	wet#2	<mdl	
252	C-4 Tk, side flge @2:00	wet	123	
254	C-7 Tk, riser flge @6:30	wet	2250	
255	C-4 Tk, side flge @2:00	wet	117	
256	C-4 Tk, riser flge @8:30	dry	178	
257	C-7 Tk, riser flge @10:00	wet	<mdl	
258	C-7 Tk, riser flge @10:00	wet#2	<mdl	
259	C-9 Tk, riser flge @11:00	wet	<mdl	
260	Piping flange above floor	wet#	6290	
261	Piping flange above floor	wet	8890	
264	C-9 Tk, riser flge @2:30	wet	<mdl	
265	C-7 Tk, riser flge @6:30	wet#2	1530	
266	C-9 Tk, riser flge @2:30	wet#2	<mdl	
268	C-9 Tk, riser flge @11:00	wet	<mdl	
269	A-1 sector, floor smear	wet	<mdl	
270	G-1 sector, floor smear	wet#2	<mdl	

Notes:
* See Table A.1.1 for general explanatory comments.
(1) There is sufficient residue on the walls of the cell pit area to indicate that the pit has been flooded at some past time.

TABLE A.3.1 (CONTINUED, PAGE 2 OF 2)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{241}Am pCi
276	G-6 sector, floor smear	wet	<mdl
277	C-8 Tk, riser flge @8:00	wet	<mdl
278	A-6 sector, floor smear	wet	<mdl
279	D-3 sector, gutter smear	wet	184
280	G-1 sector, gutter smear	wet	164
281	C-8 Tk,riser flge @11:00	wet	<mdl
282	Tunnel floor under pipes	wet	590
	AVERAGE:		**1039 pCI/smear (226%)**

MRAL-I Measurements

MEASUREMENT	LOCATION		^{241}Am
B24W10*	Floor sector G-1	(2)	6 pCi/sqcm
B24W11	Floor sector G-6		<mdl
B24W12	Floor sector C-3		55

Notes:
* This is the identification number of the spectrum stored in MRAL-I memory.
(2) Taken with a collimated detector 6 inches above the floor, viewing a 14-inch diameter circle.

TABLE A.3.2 C-CELL MEASUREMENTS - NON TRU (Page 1 of 2)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{90}SrpCi	^{137}CspCi	^{60}CopCi*
Floor smears					
269	A-1 sector, floor smear	wet	219	<mdl	100
278	A-6 sector, floor smear	wet	393	14!?	123
279	D-3 sector, gutter smear	wet	1400	74	7250
280	G-1 sector, gutter smear	wet	219	300	4790
270	G-1 sector, floor smear	wet#2	--	170	2550
276	G-6 sector, floor smear	wet	101	42	165
282	Tunnel floor under pipes	wet	131	108	161
	AVERAGES:		**410.5**	**101**	**2163**
Tank and equipment smears					
249	C-4 Tnk riser flge @8:30	wet	148	7??	5.5??
250	C-4 Tnk riser flge @8:30	wet#2	<mdl	<mdl	23.5
252	C-4 Tnk side flge @2:00	wet	273	90	85
255	C-4 Tnk side flge @2:00	wet	64	47	<mdl
256	C-4 Tnk riser flge @8:30	dry	57	<mdl	12.5!?
254	C-7 Tnk riser flge @6:30	wet	<mdl	<mdl	10.5
257	C-7 Tnk riser flge @10:00	wet	<mdl	<mdl	44
258	C-7 Tnk riser flge @10:00	wet#2	7?	<mdl	44
265	C-7 Tnk riser flge @6:30	wet#2	<mdl	<mdl	<mdl
277	C-8 Tnk riser flge @8:00	wet	18	<mdl	6.5??
281	C-8 Tnk riser flge @11:00	wet	<mdl	<mdl	<mdl
259	C-9 Tnk riser flge @11:00	wet	91	17?	1.5??
264	C-9 Tnk riser flge @2:30	wet	84	<mdl	15?
266	C-9 Tnk riser flge @2:30	wet#2	47	<mdl	41
268	C-9 Tnk riser flge @11:00	wet	13	<mdl	22.5
260	Piping flange above floor	wet#2	87	<mdl	<mdl
261	Piping flange above floor	wet	64	1??	34
	AVERAGES:		**56**	**--**	**18**
Solids					
235	A-1 sector, dust sample 29.2g		9155/g	410/g	978/g
236	A-6 sector, dust sample 40.1g		10480/g	370/g	2210/g
237	D-3 gutter, dust sample 31.1g		17386/g	517/g	20300/g (+)
238	Tunnl floor dust sample 22.7g		720/g	247/g	659/g
239	G-1 sector, dust sample 46.2g		596/g	535/g	1140/g
240	G-6 sector, dust sample 25.3g		143/g	137/g	707/g
	AVERAGES:		**6556/g(109%)**	**394/g(60%)**	**4286/g(175%)**

Note:
* See Table A.1.1 for general explanatory comments.

TABLE A.3.2 (CONTINUED, Page 2 of 2)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{90}SrpCi	^{137}CspCi	^{60}CopCi
Scraping samples					
225	C-4 Tnk, outside wall	46.5g	2595/g	6.5/g	8/g
226	C-4 Tnk in bottom flge	26.7g	5204/g	19.6/g	223/g
227	Pit East wall scrapings	16.2g	4722/g	58/g	249/g
224	C-7 Tnk in bottom flge	32.0g	3127/g	<mdl	5.5/g
228	C-7 Tnk, outside wall	42.4g	2376/g	5.5/g	43/g
AVERAGES:			**3275(22%)**	**12.2(89%)**	**75(100%)**

MRAL-I In-place measurements

ID	LOCATION/DESCRIPTION	^{137}Cs	^{60}Co
B24W10	Floor grid sector G-1 (1)	52 pCi/sqcm	425 pCi/sqcm
B24W11	Floor grid sector G-6	17	117
B24W12	Floor grid sector C-3	283	6399 (near sump)
AVERAGES:		**117.3pCi/sqcm**	**2313.7pCi/sqcm**

MRAL-II In-place measurements (2)

LOCATION/DESCRIPTION	ID	ISOTOPE/OMNI-CONCENTRATION (3)
Into C-4 tank	NA	Background only
Into C-7 tank (2)	(73,1)**	^{60}Co @28.5 nCi/L
Away from C-7 tank	(73,2)	^{60}Co @27.5 nCi/L
NET Tank wall concentration		**1.06 uCi/sqcm**
Into C-9 tank	(73,3)	^{60}Co @0.5246 uCi/L
Away from C-9 tank	(73,4)	^{60}Co @0.6862 uCi/L
NET:	Source is not inside C-9 tank.	

Notes:
** Storage identification for MRAL-II (diskette, sequence tag).
(1) Collimated detector viewing 14-inch diameter floor area.
(2) Horizontally collimated, with approx 45-degree field of view.

TABLE A.4.1 MEASUREMENTS IN D-CELL - TRU

SAMPLE	LOCATION/DESCRIPTION	TYPE		Am241pCi*	
Solids					
123	D-4 sector dust sample	49.1g		175/g	
124	G-6 sector dust sample	37.1g		100/g	
125	A-6 sector dust sample	46.6g		308/g	
126	D-1 sector dust sample	44.1g		272/g	
127	A-1 sector dust sample	47.2g		292/g	
128	2nd flr vestibule dust	23.8g		70/g	(and pigeon feces)
129	D-1 sector dust sample	23.8g		31/g	
130	Op deck, dust sample	39.5g		27/g	
	AVERAGE:			**171/g(247%)**	
Smear samples					
140	D-4 Tank, interior smear		dry	4180	
144	D-4 Tank, interior smear		wet	113,000	(+)
300	D-3 Tnk,inside riser @8:30		wet	1940	
301	D-3 Tnk,inside side flge		wet	2290	
	AVERAGE: Inside smears			**30,352(181%)**	
Floor smears					
299	A-1 sector, floor smear		wet	119	
295	A-6 sector, floor smear		wet	138	
304	D-4 sector, floor smear		wet	183	
297	D-1 sector, floor smear		wet	559	
307	G-6 sector, floor smear		wet	<mdl	
309	G-1 sector, floor smear		wet	129	
311	East wall, gutter smear		wet	297	
312	Op deck, general floor smear		wet	<mdl	
296	2nd floor vestible smear		wet	<mdl	
308	2nd floor vestibule, A-sector		wet	15700	(+)
294	D-1 Tank, flange @6:00		wet	757	
302	D-3 Tank,side flange @6:00		wet	<mdl	1 foot off
303	D-4 Tank, flange @6:00		wet	169	
298	Centrifuge, flange @2:00		wet	106	
305	Centrifuge motor air inlets		wet	476	
306	D-1 Tank, flange @8:30		wet	2390	
310	Centrifuge drain flange		wet	1890	
	AVERAGE: Flange smears			**885pCi**	

Note:
* See Table A.1.1 for general explanatory comments.

TABLE A.4.2 D-CELL MEASUREMENTS - NON TRU

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{90}SrpCi	^{137}CspCi	^{60}CopCi*
Solids					
127	A-1 sector dust sample	47.2g	147/g	145/g	32/g
125	A-6 sector dust sample	46.6g	212/g	185/g	70/g
126	D-1 sector dust sample	44.1g	180/g	154/g	12/g
129	D-1 sector dust sample	23.8g	96/g	<mdl	31/g (1)
123	D-4 sector dust sample	49.1g	258/g	283/g	19/g
124	G-6 sector dust sample	37.1g	325/g	153/g	38/g
130	Op deck, dust sample	39.5g	19/g	7.5/g	27/g (1)
128	2nd flr vestibule dust	23.8g	--	96/g	41/g
	AVERAGES:		**183/g**	**143/g**	**29.3/g**
Smear samples					
140	D-4 Tnk interior smear	dry	1361	<mdl	41
144	D-4 Tnk interior smear	wet	23984 (+)	198	<mdl
300	D-3 Tnk ins riser @8:30	wet	493	<mdl	1940
301	D-3 Tnk ins side flge	wet	235	<mdl	2290
	AVERAGE: Inside smears		**6518**	**NA**	**1424**
299	A-1 sector, floor smear	wet	--	93	26
295	A-6 sector, floor smear	wet	66	44	6.5??
297	D-1 sector, floor smear	wet	--	260	4.5??
304	D-4 sector, floor smear	wet	<mdl	81	<mdl
309	G-1 sector, floor smear	wet	53	40	3.5??
307	G-6 sector, floor smear	wet	26	48	6.5??
311	East wall, gutter smear	wet	105	403	73
296	2nd flr,vestibule smear	wet	<mdl	<mdl	<mdl
312	Op deck, general smear	wet	105	15!?	10.5!?
308	2nd flr vestibule smear	wet	1054	<mdl	<mdl
	AVERAGE: Floor smears		**176**	**98**	**13**
294	D-1 Tank flange @6:00	wet	61	593	20.5?
306	D-1 Tank flange @8:30	wet	<mdl	<mdl	25
302	D-3 Tnk,side flge @6:00	wet	3425	<mdl	<mdl
303	D-4 Tank flange @6:00	wet	81	<mdl	169
298	Centrifuge flange @2:00	wet	<mdl	<mdl	106
305	Centrifuge motor vents	wet	70	1??	<mdl
310	Centrifuge drain flange	wet	66	<mdl	<mdl
	AVERAGE: Flange smears		**740 (1)**	**NA**	**45**

Notes:
* See Table A.1.1 for general explanatory comments.
(1) Average excludes the <mdl-values.

TABLE A.4.2 (CONTINUED, Page 2 of 2)

MRAL-II In-plaqce measurements (2)

CELL LOCATION/DESCRIPTION	ID	ISOTOPE/OMNI-CONCENTRATION (3)
D-cell, into D-3 tank	(73,5)	^{137}Cs @1.5354 uCi/L
D-cell, away from D-3 tank	(73,6)	^{137}Cs @0.9771 uCi/L
NET tank wall concentration		**0.0970 uCi/sqcm** (4
D-cell, into D-4 tank	NA	Background only
D-cell, into D-1 tank	NA	Background only

Notes:
(2) Horizontally collimated detector, field of view approx 45 degrees.
(3) Equivalent response from a uniform, infinite source in sand of density 1.38.
(4) Measurement converted to concentration on inside wall of the tank.

TABLE A.5.1 E-CELL MEASUREMENTS - TRU

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{241}Am pCi*	
Solids				
114	A-1 sector dust sample	32.0g	167/g	
115	A-6 sector dust sample	33.4g	254/g	
117	D-4 sector dust sample	19.3g	14/g	
122	D-1 sector dust sample	26.2g	17/g	
113	G-1 sector dust sample	29.2g	119/g	
111	G-6 sector dust sample	24.8g	42/g	
112	2nd flr vestibule dust	26.9g	<mdl	
116	Op Deck dust sample	21.9g	<mdl	
	AVERAGE:		**89.2/g**	
Smear samples				
131	E-4 Tnk riser flge @12:30	wet	2690	
132	E-4 Tnk riser flge @12:30	wet#2	296	
134	E-4 Tnk riser flge @11:30	wet#2	1670	
135	E-4 Tnk riser flge @12:30	wet#2	406	
271	E-1 Tnk outside wall smear	wet	425	
272	E-3 Tnk, riser flge @6:30	wet	<mdl	
273	E-1 Tnk, riser flge @7:00	wet	3260	
274	E-1 Tnk, riser flge @2:00	wet	8850	
275	E-3 Tnk, side flge @3:00	wet	569	
	AVERAGE: Flange smears		**2018**	
142	E-4 Tank interior smear-A	dry	3280	
146	E-4 Tank interior smear-B	dry	314	
244	Centrifuge drain, interior	wet	84600	(+)
246	E-1 Tnk inside riser @1:00	wet	78300	
248	E-3 Tnk inside flge @3:00	wet	7610	
	AVERAGE: Interior smears		**34820**	
136	2nd flr vestibule samplr-C	dry	3500	
138	2nd flr vestibule samplr-C	wet#2	1060	
139	2nd flr vestibule samplr-C	wet	1970	
	AVERAGE: Sampler smears		**2177**	**pCi/smear**

Note:
* See Table A.1.1 for general explanatory comments.

TABLE A.5.2 E-CELL MEASUREMENTS - NON TRU

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{90}SrpCi	^{137}CspCi	Co60pCi*
Solids					
114	A-1 sector dust sample	32.0g	225/g	194/g	15/g
115	A-6 sector dust sample	33.4g	152/g	180/g	12.5/g
122	D-1 sector dust sample	26.2g	25/g	8.5/g	0.2/g??
117	D-4 sector dust sample	19.3g	56/g	5/g??	<mdl
113	G-1 sector dust sample	29.2g	88/g	63/g	4.5/g
111	G-6 sector dust sample	24.8g	71/g	26/g	<mdl
112	2nd flr vestibule dust	26.9g	1.4/g?	7.5/g	<mdl
116	Op Deck dust sample	21.9g	68/g	43/g	<mdl
	AVERAGES:		**93/g**	**75.3/g**	**9.7/g**
Smear samples					
131	E-4 Tnk riser flge @12:30	wet	--	<mdl	<mdl
132	E-4 Tnk riser flge @12:30	wet#2	--	106	<mdl
134	E-4 Tnk riser flge @11:30	wet#2	--	<mdl	4.5??
135	E-4 Tnk riser flge @12:30	wet#2	--	36	20.5
136	2nd flr vest sampler-C	dry	--	<mdl	12.5!?
138	2nd flr vest sampler-C	wet#2	--	<mdl	<mdl
139	2nd flr vest sampler-C	wet	--	<mdl	<mdl
271	E-1 Tnk outer wall smear	wet	<mdl	3??	15.5?
272	E-3 Tnk riser flge @6:30	wet	<mdl	23?	<mdl
273	E-1 Tnk riser flge @7:00	wet	149	<mdl	<mdl
274	E-1 Tnk riser flge @2:00	wet	1015	<mdl	<mdl
275	E-3 Tnk side flge @3:00	wet	<mdl	<mdl	<mdl
142	E-4 tnk interior smear-A	dry	--	771	<mdl
146	E-4 Tnk interior smear-B	dry	--	689	<mdl
244	Centrifuge drain interior	wet	9607	84	<mdl
246	E-1 Tnk ins riser @1:00	wet	2110	14100	<mdl
248	E-3 Tnk inside flge @3:00	wet	326	133	<mdl
	AVERAGES: Interior smears		**4014**	**3155**	--

Note:
* See Table A.1.1 for general explanatory comments.

TABLE A.5.2 (CONTINUED, Page 2 of 2)

MRAL-II In-place measurements		
Into E-Centrifuge (1)	(73,7)	^{137}Cs @0.5816 uCi/L
Away from E-Centrifuge	(73,8)	^{137}Cs @0.4653 uCi/L
NET tank wall concentration (2)		**0.0202 uCi/sqcm**
Into E-4 tank	(73,9)	^{137}Cs @0.4653 uCi/L
Away from E-4 tank	(73,10)	^{137}Cs @0.3954 uCi/L
NET tank wall concentration		**0.012 uCi/sqcm**
Into E-3 tank	NA	Background only
Into E-1 tank	NA	Background only

Notes:
(1) Equivalent omni-directional concentration for infinite source in sand of density 1.38 g/mL.
(2) Net concentration, estimated on first inner surface, 10 cm away from detector behind 7/16-inch steel.

TABLE A.6.1 F-CELL MEASUREMENTS - TRU (Page 1 of 2)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{241}AmpCi*	
Floor smears				
188	A-2 floor sector smear	wet	<mdl	
191	E-1 floor sector smear	wet	245	
176	E-4 floor sector smear	wet	102	
173	G-4 floor sector smear	wet	157	
182	H-5 floor sector smear	wet	567	
185	J-1 floor sector smear	wet	137	
	AVERAGE:		**201 pCi/smear**	
179	Main floor sump	wet	6250	
Flange smears				
149	G-1 Centfge,riser flge	wet	<mdl	
152	G-7 Centfge,riser flge	wet	<mdl	
157	E-1 sector, lower flge	wet	96500	(+)
161	F-2 Centrifuge, cover	wet	648	
164	F-22 Centrifuge, cover	wet	504	
167	F-1 Tnk, cover smear	wet	1830	
170	F-1 Tnk, riser @3:00	wet	346	
194	F-1 Tnk side flge @2:30	wet	370	
334	F-1 Tank, riser @3:00	wet	5760	
335	F-1 Tank, riser @3:00	wet#2	7630	
206	F-7 Tank, riser @3:30	wet	322	
208	F-7 Tank, cover	wet	489	
212	F-8 Tank, cover	wet	902	
215	F-8 Tank, riser @3:00	wet	<mdl	
197	F-8 Tnk side flge @6:00	wet	574	
332	F-8 Tank, riser @3:00	wet#2	2410	
333	F-8 Tank, side @6:00	wet	685	
336	F-8 Tnk side flge @6:00	wet#2	2470	
337	F-8 Tank, riser @3:00	wet	1130	
200	F-9 Tank, riser @3:30	wet	<mdl	
203	F-9 Tank, cover	wet	1580	

Note:
* See Table A.1.1 for general explanatory comments.

TABLE A.6.1 (CONTINUED, Page 2 of 2)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{241}Am pCi	
158	Op deck, sampler flange	wet	7550	
339	Vestibule sampler flange	wet	14500	
340	Vestibule sampler flange	wet#2	10000	
338	A-4 sector, header flange	dry	432	
343	A-4 sector, header flange	wet	946	
344	A-4 sector, header flange	wet#2	941	
341	E-1 sector, flange smear	wet	64900	Pu=77nCi
342	E-1 sector, flange smear	wet#2	44400	Pu=888nCi
	AVERAGE: Flange smears		**9232(238%)**	
Solids				
217	Main sump, dust sample 42.4g		8400/g	
223	A-2 sector, dust sample 29.7g		582/g	
220	A-4 sector, dust sample 42.6g		510/g	
222	E-2 sector, dust sample 38.0g		2990/g	
219	E-4 sector, dust sample 33.4g		559/g	
218	H-5 sector, p-feces 20.6g		56/g	
221	J-1 sector, dust sample 22.3g		260/g	
	AVERAGE:		**2326/g(169%)**	
MRAL-I In-place measurements				
B24W13	FLOOR SECTOR A-4		153pCi/sqcm (1)	
B24W14	FLOOR SECTOR F-5		77	
B24W15	SUMP, SECTOR F-5		2010	
B24W16	FLOOR SECTOR J-5		9	
B24W17	2ND LEVEL, SECTOR F-3		20	
B24W18	2ND LEVEL, SECTOR A-1		11	
B24W19	FLOOR SECTOR H-1		18	
MRAL-II In-place measurement ID				
F-cell, F-10 loadout hood		(100,1)	^{241}Am @0.68mCi (2) (3)	

Notes:
(1) Measurements made using downlooking detector viewing 14-inch diameter floor area.
(2) Measurement with borehole detector placed in sump of hood.
(3) Equivalent total concentration based on a sphere of 1.5 foot radius.

TABLE A.6.2 F-CELL MEASUREMENTS - NON TRU

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{90}SrpCi	^{137}CspCi	Co60pCi*
Floor smears					
188	A-2 floor sector smear	wet	50	101	17.5?
191	E-1 floor sector smear	wet	50	28	9.5!?
176	E-4 floor sector smear	wet	98	74	<mdl
173	G-4 floor sector smear	wet	<mdl	36	<mdl
182	H-5 floor sector smear	wet	111	258	<mdl
185	J-1 floor sector smear	wet	202	632	19.5?
	AVERAGES:		**85**	**188**	**7.8**
179	Main floor sump	wet	895	6018	29.5
Flange smears					
149	G-1 Centfge riser flange	wet	54	<mdl	15.5!?
152	G-7 Centfge riser flange	wet	57	<mdl	<mdl
157	E-1 sector, lower flange	wet	690	<mdl	11.5!?
161	F-2 Centrifuge, cover	wet	97	24	<mdl
164	F-22 Centrifuge, cover	wet	34	<mdl	<mdl
167	F-1 Tank, cover smear	wet	831	298	<mdl
170	F-1 Tank, riser @3:00	wet	232	<mdl	<mdl
194	F-1 Tank side flge @2:30	wet	<mdl	<mdl	<mdl
206	F-7 Tank, riser @3:30	wet	67	<mdl	28.5
208	F-7 Tank, cover	wet	<mdl	86	<mdl
212	F-8 Tank, cover	wet	286	251	311
215	F-8 Tank, riser @3:00	wet	<mdl	<mdl	31.5
197	F-8 Tnk side flge @6:00	wet	138	14!?	<mdl
200	F-9 Tank, riser @3:30	wet	100	<mdl	<mdl
203	F-9 Tank, cover	wet	255	209	<mdl
332	F-8 Tank, riser @3:00	wet#2	--	11!?	7.5!?
333	F-8 Tnk side flge @6:00	wet	--	13!?	<mdl
334	F-1 Tank, riser @3:00	wet	--	<mdl	9.5!?
335	F-1 Tank, riser @3:00	wet#2	--	5??	<mdl
336	F-8 Tnk side flge @6:00	wet#2	--	13!?	<mdl
337	F-8 Tank, riser @3:00	wet	--	<mdl	17?

Note:
* See table A.1.1 for general explanatory comments.

TABLE A.6.2 (CONTINUED, Page 2 of 3)

SAMPLE	LOCATION/DESCRIPTION	TYPE	^{90}SrpCi	^{137}CspCi	^{60}CopCi
158	Op deck, sampler flange	wet	2123	839	<mdl
338	A-4 sector, header flge	dry	--	<mdl	<mdl
343	A-4 sector, header flge	wet	--	13!?	<mdl
344	A-4 sector, header flge	wet#2	--	<mdl	<mdl
339	Vestibule sampler flange	wet	--	3??	<mdl
340	Vestibule sampler flange	wet#2	--	29	<mdl
341	E-1 sector, flange smear	wet	--	15!?	<mdl
342	E-1 sector, flange smear	wet#2	--	90	5??
	AVERAGE: Flange smears		--	**124**	**NA**
Solids					
217	Main sump, dust sample	42.4g	2327/g	3319/g	<mdl
223	A-2 sector, dust sample	29.7g	3338/g	564/g	<mdl
220	A-4 sector, dust sample	42.6g	708/g	518/g	<mdl
222	E-2 sector, dust sample	38.0g	5374/g	942/g	<mdl
219	E-4 sector, dust sample	33.4g	1609/g	666/g	<mdl
218	H-5 sector, p-feces	20.6g	148/g	53/g	<mdl
221	J-1 sector, dust sample	22.3g	898/g	549/g	<mdl
	AVERAGES:		**2227(95%)**	**1098(132%)**	--
MRAL-I In-place measurements					
B24W13	FLOOR SECTOR A-4	(1)	--	17	<MDL
B24W14	FLOOR SECTOR F-5		--	60	<MDL
B24W15	SUMP, SECTOR F-5		--	950	<MDL
B24W16	FLOOR SECTOR J-5		--	31	<MDL
B24W17	2ND LEVEL, SECTOR F-3		--	31	<MDL
B24W18	2ND LEVEL, SECTOR A-1		--	27	<MDL
B24W19	FLOOR SECTOR H-1		--	17	<MDL
MRAL-II In-place measurements					
Into F-1 tank		NA	Background only		
Into F-7 tank		(73,11)	^{137}Cs @0.5583 uCi/L		
Away from F-7 tank		(73,12)	^{137}Cs @0.2559 uCi/L		
	NET tank wall concentration		**0.053 uCi/sqcm**		

TABLE A.6.2 (CONTINUED, Page 3 of 3)

MRAL-II In-place measurements		
Into F-8 tank	(73,13)	^{137}Cs @2.0007 uCi/L
Away from F-8 tank	(73,14)	^{137}Cs @1.6983 uCi/L
NET tank wall concentration		**0.528 uCi/sqcm**
Into F-9 tank	(73,15)	^{137}Cs @0.9538 uCi/L
Away from F-9 tank	(73,16)	^{137}Cs @0.7212 uCi/L
NET tank wall concentration		**0.407 uCi/sqcm**
F-10 loadout hood	(100,1)	^{137}Cs @26.9 nCi/L 18.56 nCi (total, ^{137}Cs)
Mech room, air intake	(100,2)	^{137}Cs @2.187 nCi/L 1.51 nCi (total, ^{137}Cs)**

Notes:
(1) Measurements view a 14-inch diameter circle of floor.
(2) Detector was horizontally collimated with a viewing window of approx 45 degrees.
(3) Equivalent omni-directional, uncollimated concentration of a uniform, infinite source.
** No other isotopes identified.

SD-DD-TRP-002

APPENDIX B

GENERAL SURVEY RESULTS (Facility Sketches)

General Summary of Survey Conducted at 224-B:

Ervin C. Marten
RPT B-Plant
1/24/85

During the week of 11/26/84 we started surveying in the A-Cell of 224-B (Plutonium Processing Facility - shutdown since 1953) in preparation for future Decontamination and Decommissioning procedures. There are gross amounts of bird droppings and carcasses throughout the cell areas with heaviest concentrations in the E-Cell area. A great amount of dust has also accumulated over the 30 years since processing was haulted. Relamping had to be conducted before surveying could begin. There are several ladders in various cells which were useful in climbing up onto tanks. A make-shift deck is in place over the E-Cell and is constructed from 2"x8" planks and plywood. A, B and D cells have a centrifuge located on the operating decks. The E-Cell centrifuge had been removed to the cell floor some time in the past. C-Cell has no operating deck. There is a Bridge Chain Hoist available and presently situated over the E-Cell area.

CAUTION: When opening the operating deck doors a strong air flow exists into the cells from the gallery. A lesser negative air flow exists when opening the south wall doors that open into the cells proper. If both doors are open at the same time the stronger air flow from the gallery will overcome the lesser air flow from outside and air will escape into the outside atmosphere.

There is 110V electrical power supplied to the cells but an adaptor is required to allow present plugs to be connected to the outlets.

An extensive number of smears and direct readings were taken in each area as per the grid for A-Cell. These smears and direct readings were taken for Alpha, Beta and Gamma Radioactive Contamination and all smears were sent to the Radionuclide Analysis Laboratory (RAL) at REDOX for further analysis. Neutron surveys were taken in each cell with a Snoopy. Air samples were also taken in each cell along with dust scrapings and bird droppings which were also sent to RAL.

As a result of information collected in the A-Cell, surveying was limited in the remainder of the cells to only the areas indicated on each grid. An overall direct survey was taken with a GM with P-11 Probe and a PAM in all cells and then smears were taken at the highest areas of contamination. The major work was completed in about three weeks.

Generally contamination was minimal (see grids) and there has been no spread outside the cells as a result of the numerous entries and exits. All entries are being made in two sets of SWP clothing and filter mask. Smears and direct readings were taken randomly in the galleries, all of which were found to read less than background. Step-off Pads were smeared regularly and were shown to read less than background.

/

General Summary of Survey Conducted at 224-B (Continued):

Page Two

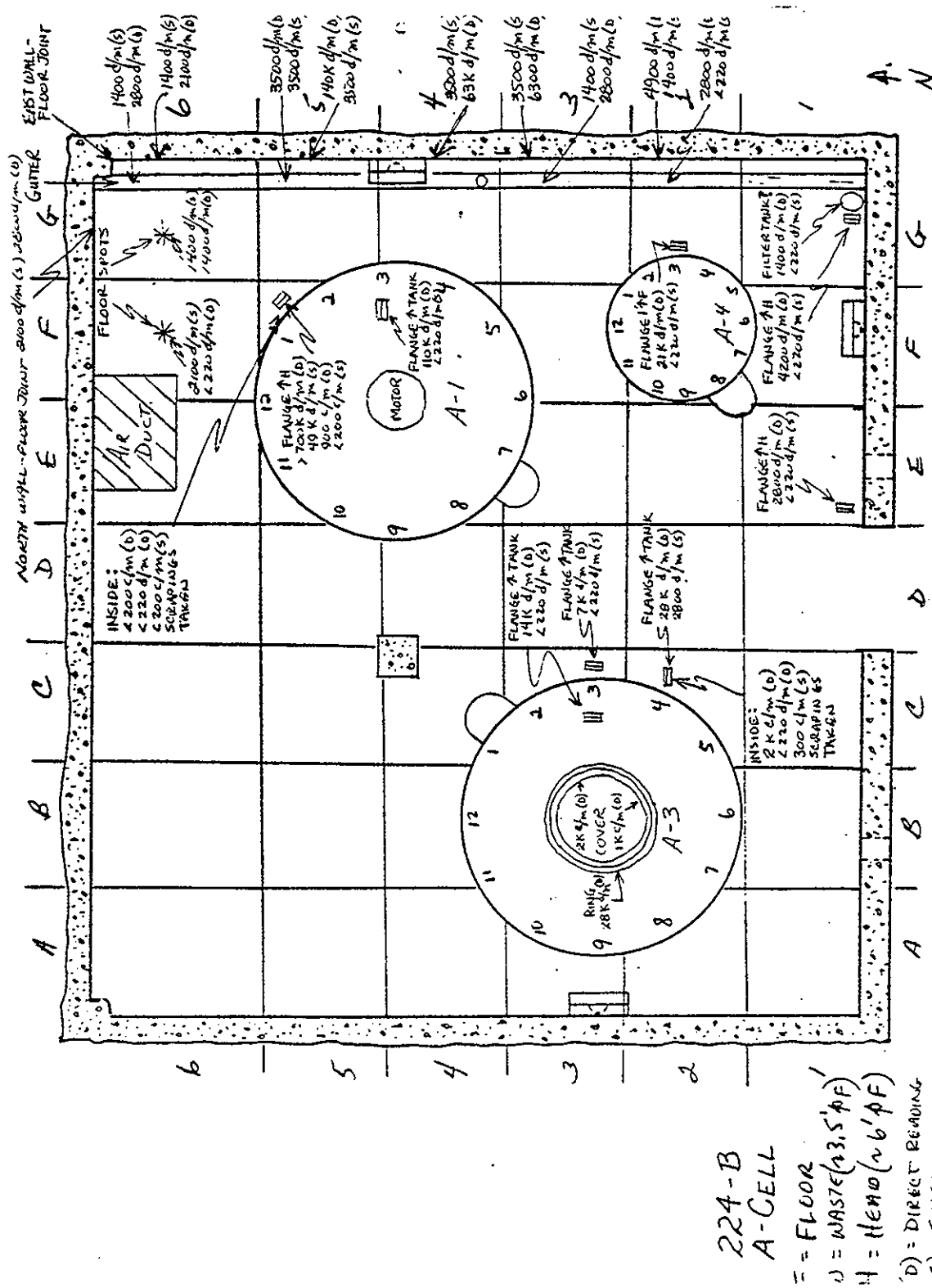
A pipefitter was called in and flanges were opened in A, D, E and F cells for smears and scrapings inside of piping and tanks as possible. Further data should be collected in the Ventillation Fan Room and the Product Load-out Room (located inside 225-B storage area on the north side of F-Cell). The Bridge Chain Hoist has been load tested to 4000 pounds but cleaning needs to be conducted to allow movement up and down the canyon.

Refer to John Gould at RAL for isotopic results of samples collected. Amounts of Americium, Cobalt, Cesium and Strontium were detected in various areas. Refer to grids for location and definitive data as collected by RPT.

Future work is to include Photography by Battelle and excavation at the Southwest corner of the building to take data in the Vessel Vent Piping.

E.C. Marten

2


224-B
A-CELL
= FLOOR
J = WASTE (23,5'AF)
H = HEAD (26'AF)
(D) = DIRECT READING
(S) = SWIPEAK
NOTE: SEE DRAWING SD-DD-TRP-003 FOR DETAIL DATA.
NORTH WALL - FLOOR JOINT 2800 d/m (S) 2200 c/m (D)
EAST WALL - FLOOR JOINT
GUTTER
FLOOR SPOTS
AIR DUCT
INSIDE: <200 c/m (D) <220 d/m (D) <200 c/m (S) SCRAPINGS TAKEN
MOTOR
A-1
A-3
A-4
RING 28K d/m (D)
2K d/m (D) COVER 1K c/m (D)
INSIDE: 2K c/m (D) <220 d/m (D) 300 c/m (S) SCRAPINGS TAKEN
FILTER TANK 1400 d/m (D) <220 d/m (S)

224-B A-CELL:

(1) DOSE RATES TO PERSONNEL: < 1 mrRem/HR

(2) ALL AREAS: < 200 c/m (D) & (S) UNLESS OTHERWISE
< 220 d/m (D) & (S) INDICATED

(3) ON READINGS TAKEN IN AREAS A-3, C-4, D-6, F-1 & G-4, ALL READINGS < .1 mRem/HR (THREE READINGS TAKEN ALONG EAST WALL-FLOOR JOINT < .1 mRem/HR)

(4) DUST SAMPLES COLLECTED IN AREAS A-1, D-1, F-6 & G-1.

(5) BIRD DROPPINGS COLLECTED IN AREA D-2.

(6) AIR SAMPLE TAKEN 11-28-84, TAKEN IN AREA E-3 AT WASTE HIGH FROM 1:47 PM THROUGH AT LEAST 3:00 PM. (FUSE IN SAMPLER BLEW OUT SO EXACT TIME OF SAMPLE IS UNKNOWN.)

(7) TANK A-1 RISER FLANGES: < 200 c/m (D) & (S) EXCEPT
< 220 d/m (S) AS FOLLOWS
700 d/m - 110 K d/m (D) ALL FLANGES

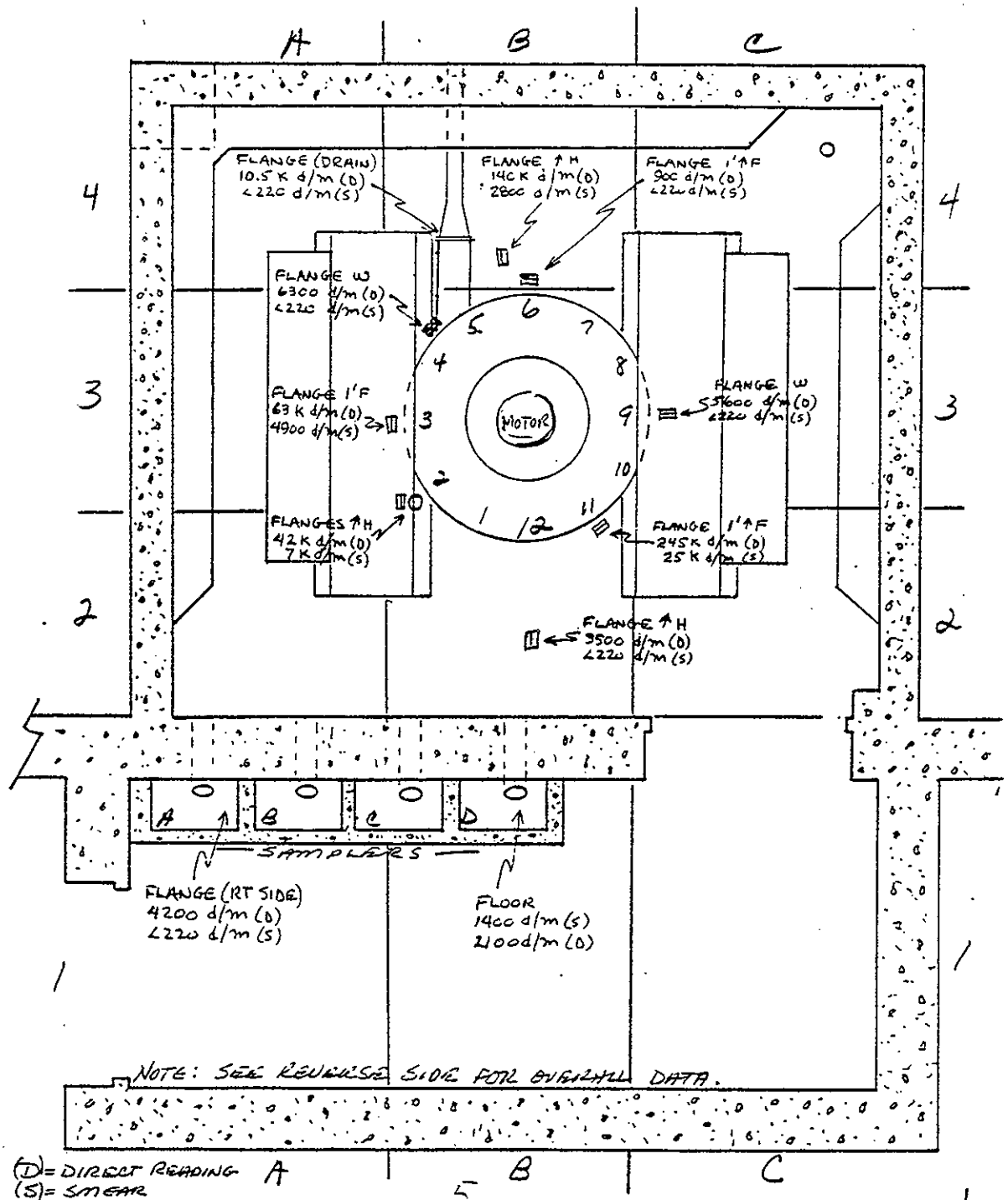
2:00 — 2800 d/m (S)
3:00 — 2800 d/m (S)

(8) TANK A-3 RISER FLANGES: < 200 c/m (D) & (S)
< 220 d/m (S)
700 d/m - 160 K d/m (D)
} ALL FLANGES

(9) TANK A-4 RISER FLANGES: < 200 c/m (D) & (S)
< 220 d/m (S)
700 d/m - 2800 d/m (D)
} ALL FLANGES

11-26-84 THROUGH 11-30-84
E.C. MARTEN
RPT
INSTRUMENTATION:
CP, GM #R-11, PRM #SNOOPY

4



CELL (A), B, OR D VESTIBULE & OPERATING DECK

F = FLANN W = WASTE (~3.5'↑A.C.) H = HEAD (~6'↑A.F.)

224-B A-CELL VESTIBULE & OPERATING DECK:

(1.) ALL AREAS: < 200 c/m DIRECT(D) & SMEARABLE(S)
< 220 d/m DIRECT(D) & SMEARABLE(S)
UNLESS OTHERWISE INDICATED

(2.) 'N' READING TAKEN WITH SNOOPY AT 11:30 ON CENTRIFUGE LID = < .1 mRem/HR

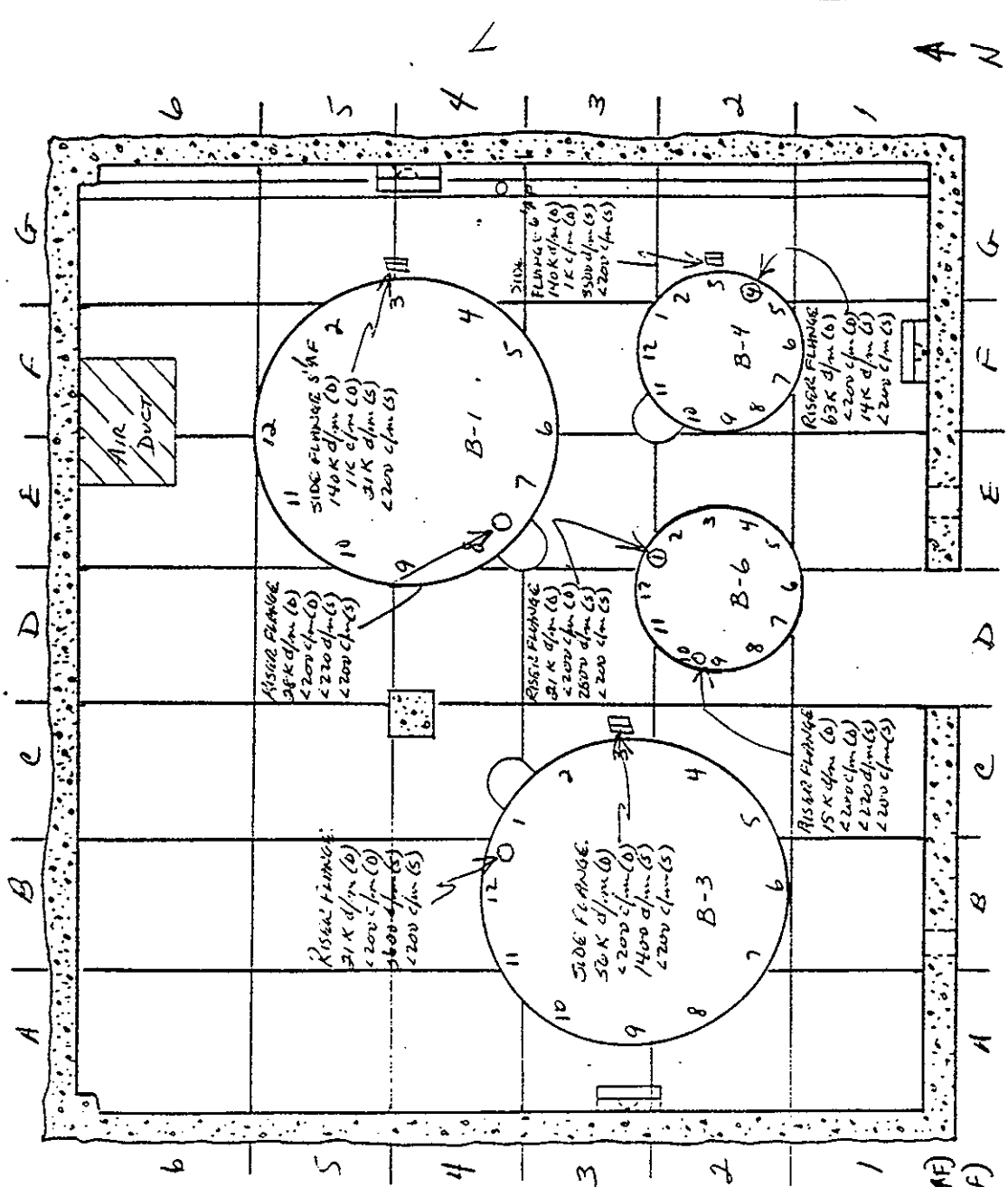
(3.) CENTRIFUGE RISER FLANGES:
5:00 - 1400 d/m (S) & 63 K d/m (D)
6:00 - 700 d/m (S) & 42 K d/m (D)
ALL OTHERS: < 220 d/m (S) & 700 d/m (D)

(4.) CENTRIFUGE COVER GASKET:
< 220 d/m (S) & 56 K d/m (D)

(5.) DOSE RATES TO PERSONNEL: < 1 mRAD/HR

11-26-84 THROUGH 11-30-84
E.C. HARTEN
RPT
INSTRUMENTATION:
CP, GM & P-11, PAM & SNOOPY

6


AIR DUCT
B-1
B-3
B-4
B-6
224-B
B-CELL
F = FLOOR
W = WASTE (N35'NF)
H = HEAD (N 61'NF)
(D) = DIRECT
(S) = SMEARED
NOTE: SEE RISER SIZE AND OVERALL DATA.

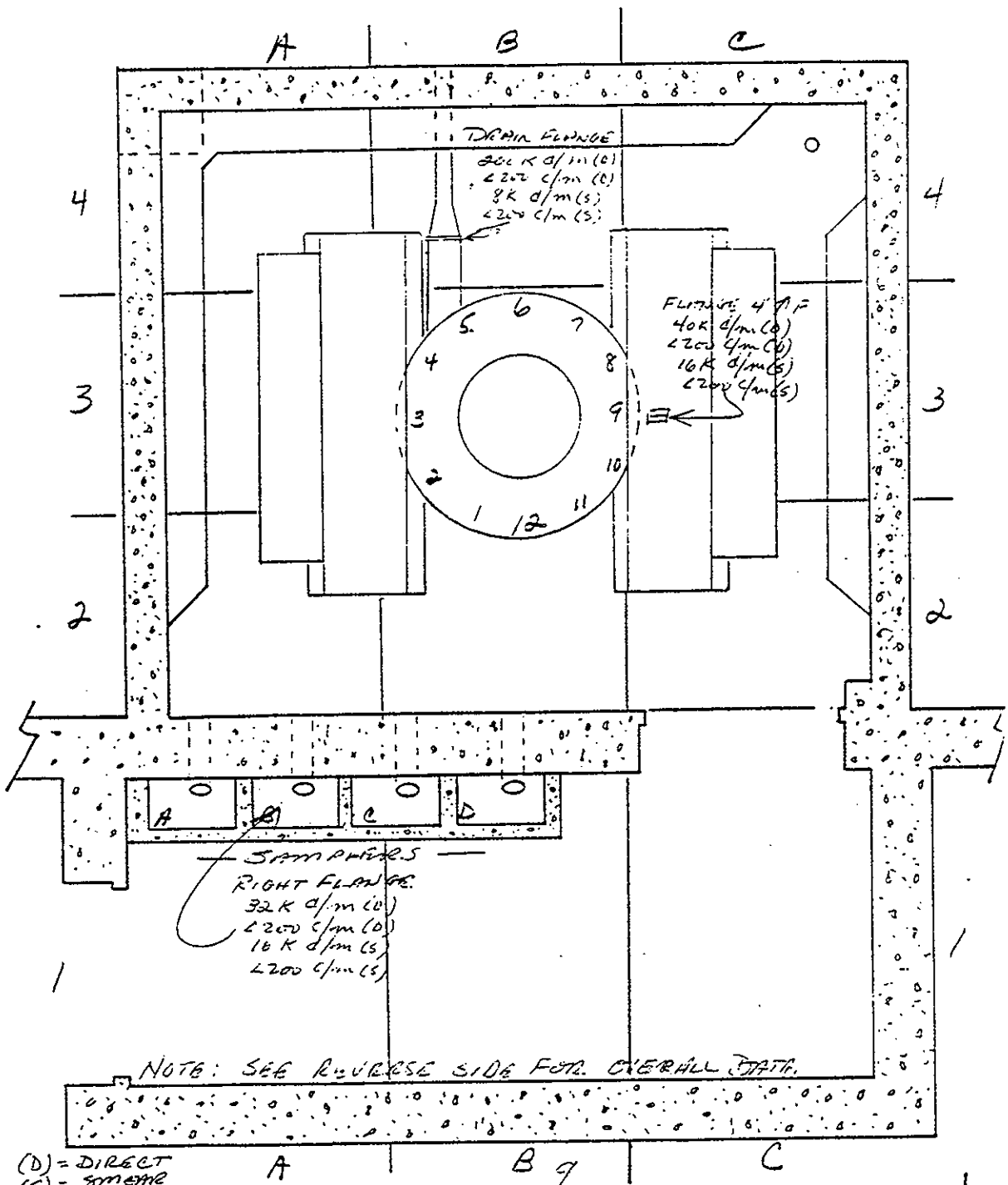
324-B B-CELL:

1. DOSE RATE TO PERSONNEL < 1 mR/HR.
2. ONLY SOLICITED AREAS SURVEYED.
3. 6" READINGS TAKEN IN AREAS C-2, C-4, E-3 & E-4, F-2 (ON RECHAMBER) & F-6. ALL READINGS < .3 mREM/HR.
4. DUST & DROPPINGS COLLECTED IN AREAS A-1, A-6, G-1 & G-6.

12-10-84 THROUGH 12-14-84
E.C. HEATH
RPT
INSTRUMENTATION:
CP, GM & P-11, PANT & SNOOPY

5. AIR SAMPLE TAKEN IN AREA D-3.

8


A
B
C
4
3
2
1
DRAIN FLANGE
20K d/m (D)
L200 c/m (D)
8K d/m (S)
L200 c/m (S)
FLANGE 4' AF
40K d/m (D)
L200 c/m (D)
16K d/m (S)
L200 c/m (S)
SAMPLERS
RIGHT FLANGE
32K d/m (D)
L200 c/m (D)
16K d/m (S)
L200 c/m (S)
NOTE: SEE REVERSE SIDE FOR OVERALL DATA.
(D) = DIRECT
(S) = SYNERGE
CELL A, (B), OR D VESTIBULE & OPERATING DECK
N

224-B E-CELL, VESTIBULE & OPERATING DECK:

(1.) DOSE RATE TO PERSONNEL < 1 mR/HR.

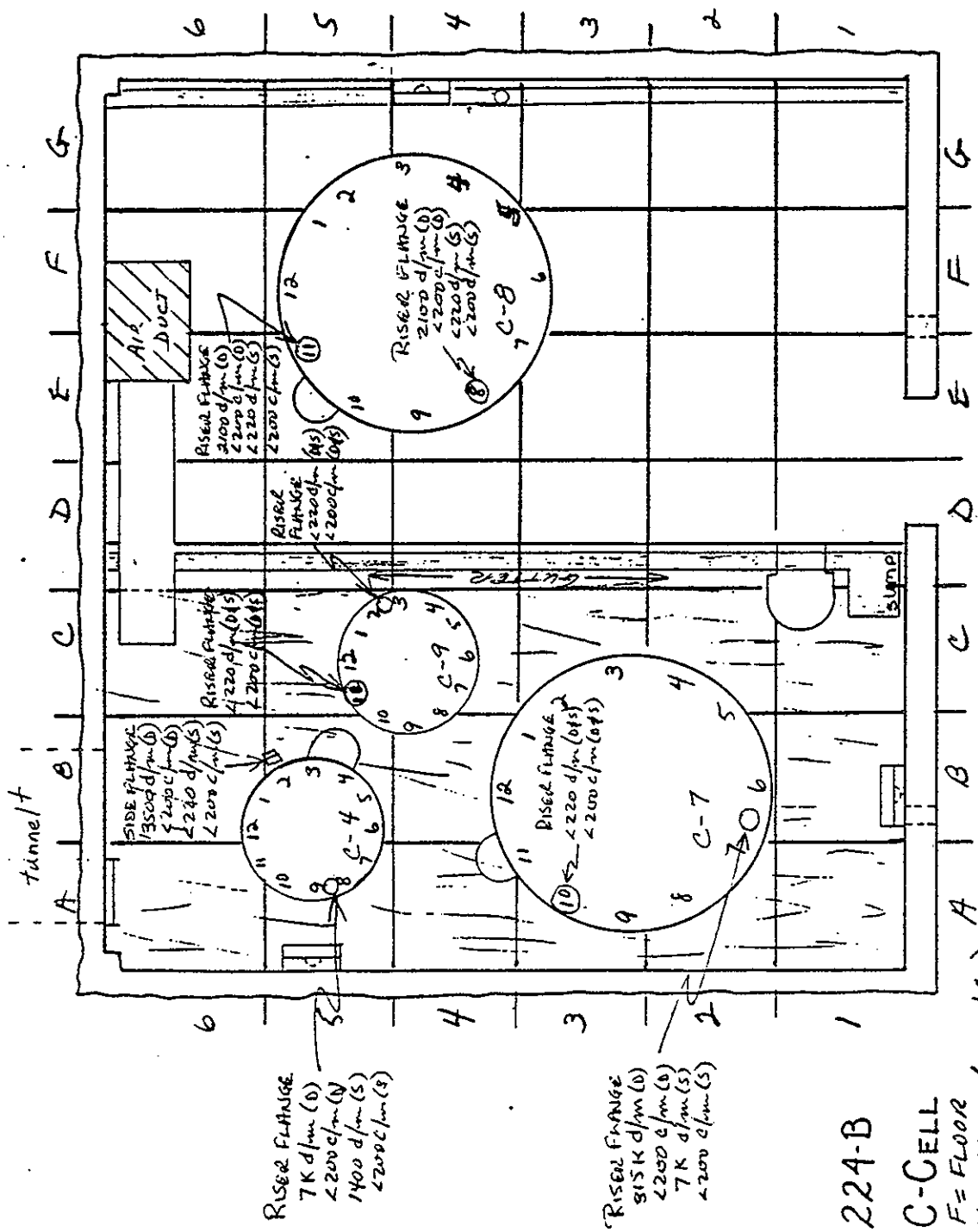
(2) ONLY CALCULATED AIRBORNE SOURCE.

(3) 2 N READINGS TAKEN IN ROOMS 1-2 & 1-4.
RESULTS < 1 x 10⁻⁶ μCi/ml.

(4) TWO AIR SAMPLES COLLECTED IN ROOMS
1-1 & 1-4.

12-10-84 THROUGH 12-14-84
E.C. RIHA TEN
KPT
INSTRUMENTATION:
(2) GM & PIC, FIXED & SWOOPY

10


224-B
C-CELL
F = FLOOR
W = WASTE (@ 3,5' & 11' F)
H = HEAD (@ 6' & 11' F)
(D) = DIRECT
(S) = SIPHONIC
NOTE: OVERALL DATA ON REVERSE.
AIR DUCT
GUTTER
SUMP
RISER FLANGE 2100 d/m (D) ∠2200 c/m (D) ∠2200 d/m (S) ∠2200 c/m (S)
RISER FLANGE ∠2200 d/m (D&S) ∠2200 c/m (D&S)
RISER FLANGE ∠2220 d/m (D&S) ∠2200 c/m (D&S)
SIDE FLANGE 13500 d/m (D) ∠2250 c/m (D) ∠2250 d/m (S) ∠2200 c/m (S)
RISER FLANGE 7K d/m (D) ∠2200 c/m (D) 1400 d/m (S) ∠2200 c/m (S)
RISER FLANGE 9.5K d/m (D) ∠2250 d/m (D) 7K d/m (S) ∠2200 d/m (S)
C-8
C-9
C-4
C-7
tunnel

224-B C-CELL:

(1) DOSE RATE TO PERSONNEL:
- (a) EAST HALF (D, E, F & G AREAS) < 1 mRAD/HR.
- (b) WEST HALF (PIT - A, B & C AREAS) 3 mRAD/HR.
- (c) TUNNEL (FIELD) 3 mRAD/HR.
  20 mR/HR CONTACT WITH PIPING IN PIPE RUN.

(2) ONLY SELECTED AREAS SURVEYED.

(3) 14 READINGS TAKEN IN AREAS A-4, B-1, B-4, TUNNEL, F-3 & F-5. ALL READINGS < .1 mREM/HR

(4) C-CELL SAMPLER: SAMPLER "C" RIGHT FLANGE — 320 K d/m (D), 64 K d/m (S), 300 c/m (D) & < 200 c/m (S).

(5) AREA SURVEYS:

A-1	< 220 d/m (D&S) < 200 c/m (D&S)	TUNNEL	6300 d/m (D) 2800 d/m (S) 500 c/m (D) 300 c/m (S)
A-6	< 220 d/m (D&S) < 200 c/m (D&S)	G-1	700 d/m (D) < 200 d/m (S) 400 c/m (D) < 200 c/m (S)
PIT AREA GUTTER	1400 d/m (D) < 220 d/m (S) < 200 c/m (D&S)	G-6	1400 d/m (D) < 220 d/m (S) < 200 c/m (D&S)

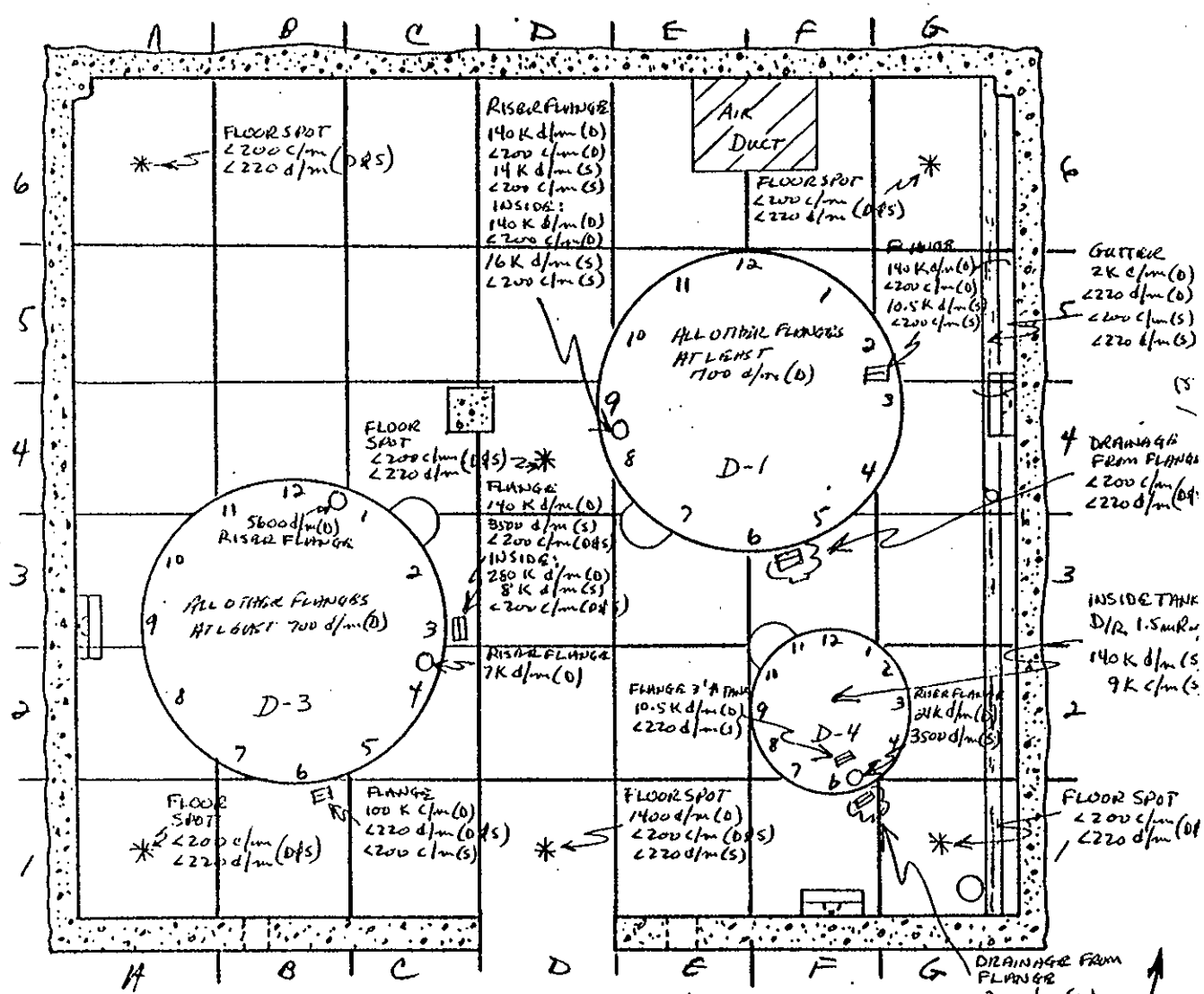
(6) AIR SAMPLES TAKEN IN AREAS E-3 AND MOUTH OF TUNNEL.

(7) DUST & DROPPINGS COLLECTED IN AREAS A-1, A-6, TUNNEL, PIT AREA GUTTER, G-1 & G-6.

(8) SCRAPINGS TAKEN ON TANKS C-4, C-7, EAST PIT WALL, BOTTOM FLANGE ON TANKS C-4 & C-7. SIDES

12-10-84 THROUGH 12-14-84
E.C. MARTEN
RDT
INSTRUMENTATION:
NO Cm & C-11 Dam & SNOOPY

12



NOTE: SEE REVERSE SIDE FOR OVERALL DATA.

224-B

D-CELL

F = FLOOR

// = WASTE (~3.5' A F) (D) = DIRECT

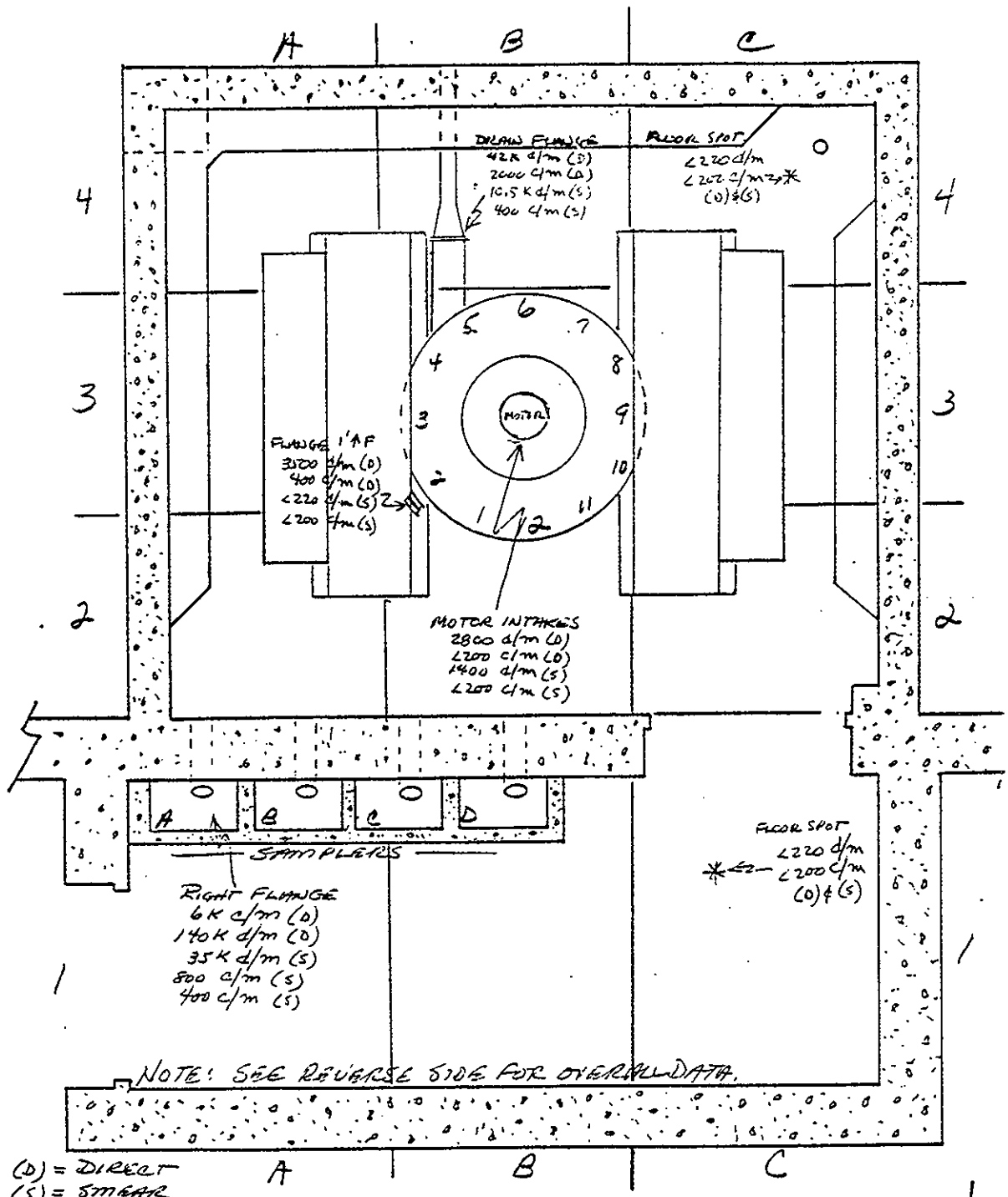
// = HEAD (~6' A F) (S) = SIDEARM

224-B D-CELL:

1. D/R TO PERSONNEL < 1 mRAD/HR.
2. ONLY SELECTED AREAS SURVEYED.
3. 1N READINGS TAKEN IN AREAS A-2, C-3, E-6, F-1, AND G-2.
4. DUST & DROPPINGS COLLECTED IN AREAS A-1, A-6, D-1, D-4, G-1 AND G-6.
5. SWIPES TAKEN IN D-4 TANK ABOUT HALF WAY DOWN INSIDE.

E. C. MARTEN
RPT
12-3-84 THROUGH 12-7-84
INSTRAMENTATION:
CP, GM & P-11, PAM & SNOOPY

14



CELL A, B, OR (D) VESTIBULE & OPERATING DECK

F = FLOOR W = WASTE (~3.5'AF) H = HEAD (~6'AF)

15

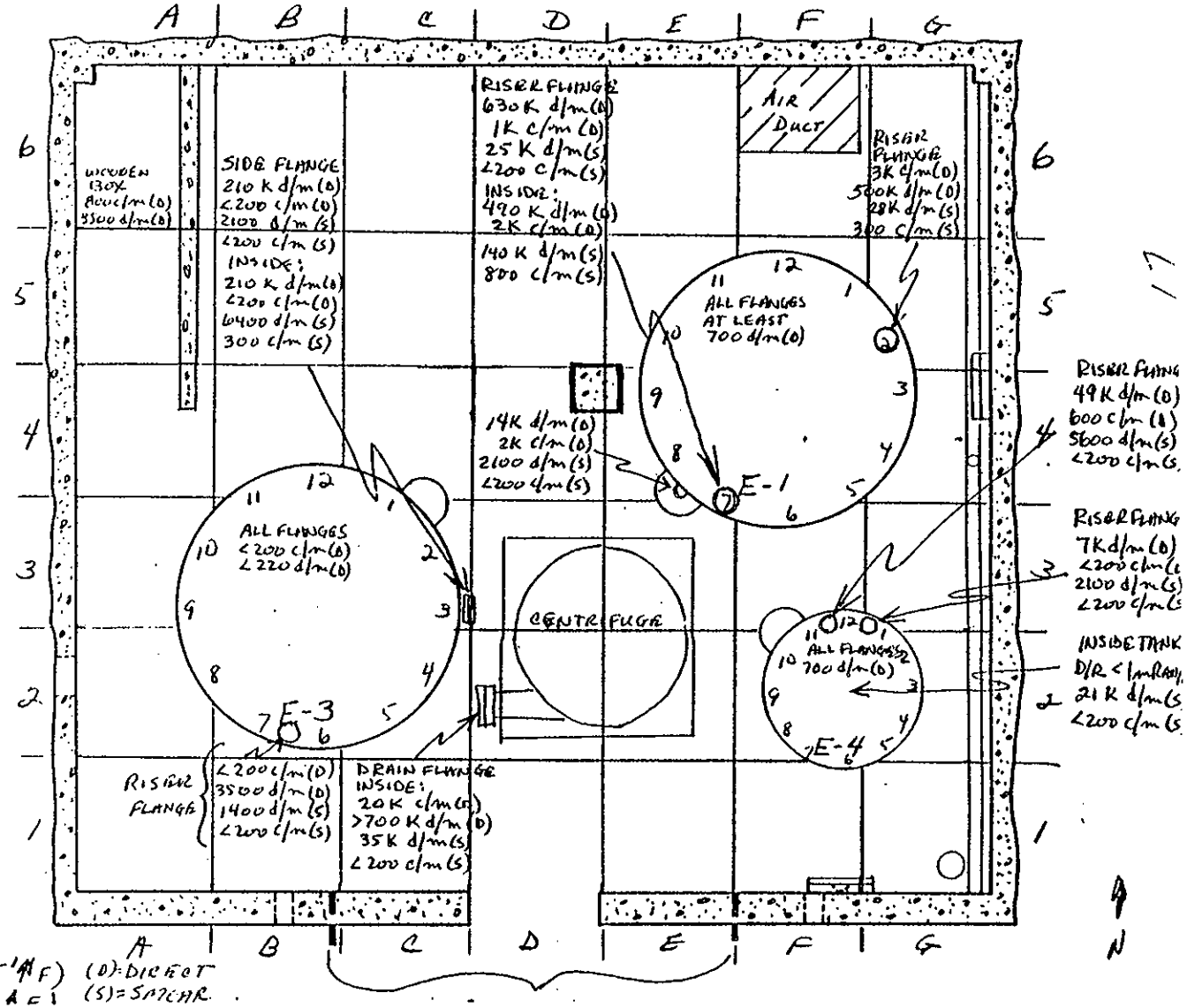
N

234-G D-CELL VESTIBULE & OPERATING DECK:

1. D/R TO PERSONNEL < .1 mRAD/HR.
2. ONLY SELECTED LOCATIONS SURVEYED & HOTEST FLANGES SMEARED AS INDICATED ON GRID ON REVERSE SIDE.
3. 1'N READINGS TAKEN AT FLOOR LEVEL AT 12:00 AND 6:00 (BASE OF CENTRIFUGE) — < .1 mREM/HR.
4. DUST SAMPLES COLLECTED AREAS C-1 & C-4.

E.C. MARTEN
RPT
12-3-84 THROUGH 12-7-84
INSTRUMENTATION:
CP, GM & PIC, PAM & SNOOPY

16



NOTE: SEE REVERSE SIDE FOR OUTFALL DATA.

224-B

E-CELL

F = FLOOR
W = WASTE (~3.5' AFF) (D) = DIGEST
H = HEAD (~6.5' AFF) (S) = SATCHR.

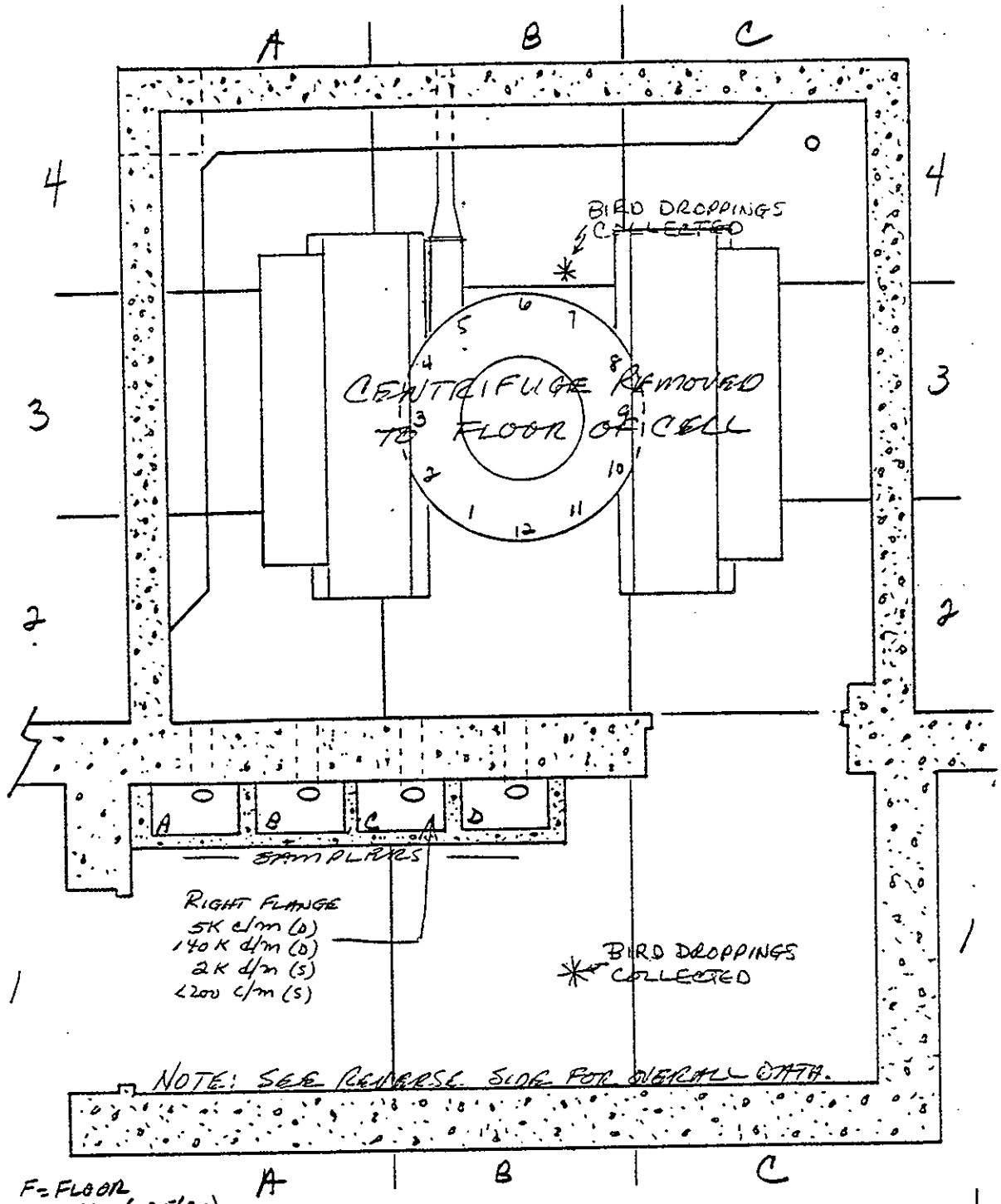
224-B E-CELL!

1. D/R TO PERSONNEL < 1 mRAD/HR.
2. ONLY SELECTED LOCATIONS SURVEYED.
3. 6 N READINGS TAKEN IN AREAS A-1, E-4, BOTH SIDES OF CENTRIFUGE, F-1, F-3 AND F-5. RESULTS: < .1 mRAD/HR.
4. DUST & DROPPINGS COLLECTED IN AREAS A-1, A-6, D-1, D-4, G-1 & G-6.

E. CONTAMINATION RPT
12-3-84 THROUGH 12-7-84
INSTRUMENTATION:
CP, GM & P-11, RAM & SNOOPY

5. SWIPES TAKEN IN E-4 TANK ABOUT HALF DOWN INSIDE.

18

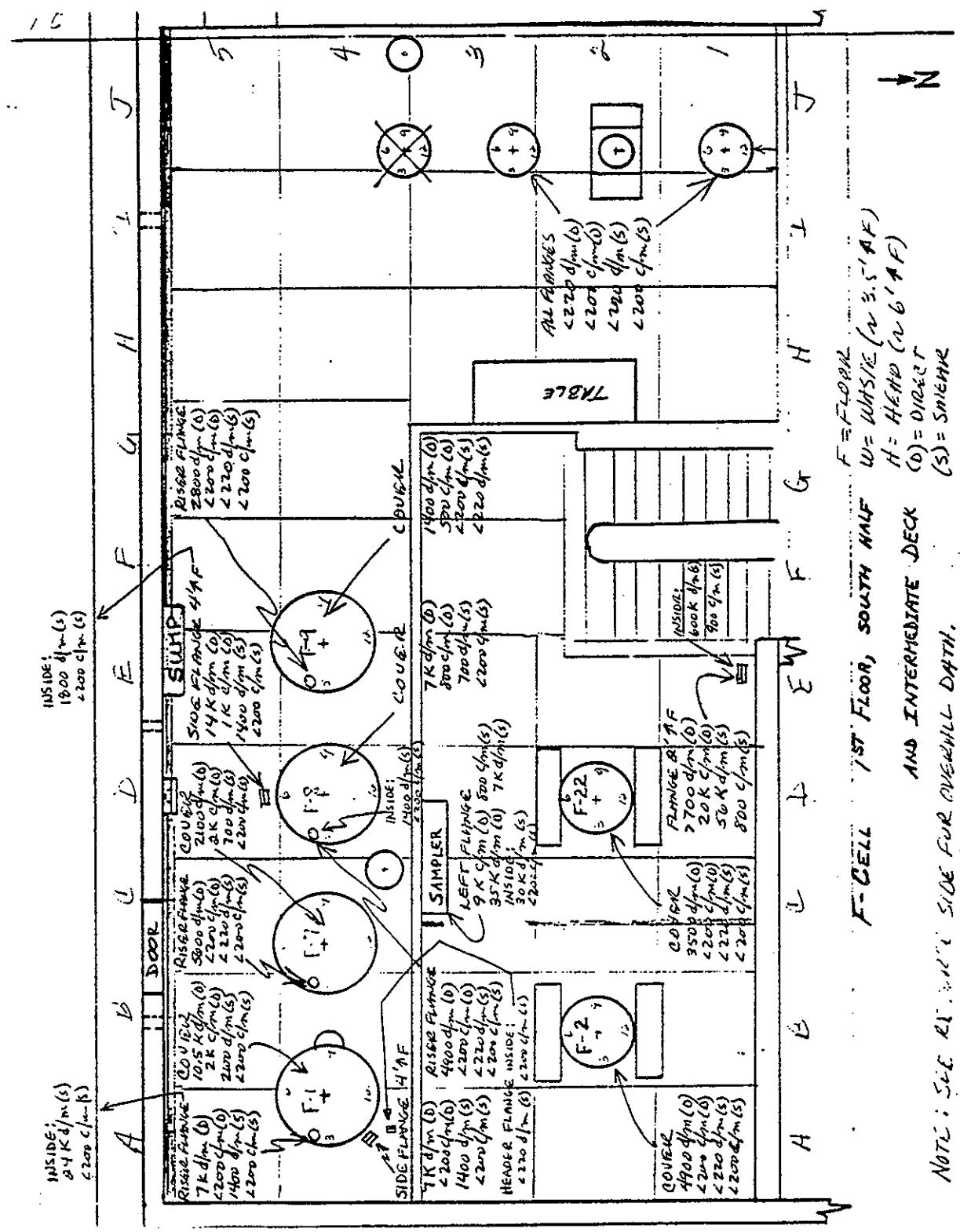

A
B
C
4
3
2
1
BIRD DROPPINGS COLLECTED
CENTRIFUGE REMOVED TO FLOOR OF CELL
SAMPLERS
RIGHT FLANGE
5K c/m (D)
140K d/m (D)
2K d/m (S)
<200 c/m (S)
BIRD DROPPINGS COLLECTED
NOTE: SEE REVERSE SIDE FOR OVERALL DATA.
F = FLOOR
W = WASTE (~2.5' AF)
H = HEAD (~6' AF)
(D) = DIRECT
E-CELL VESTIBULE & OPERATING DECK / 9
N

224-B E-CELL VESTIBULE & OPERATING DECK:

1. D/R TO PERSONNEL < 1 mRad/HR.
2. ONLY SELECTED LOCATIONS SURVEYED
   i.e. SAMPLERS AND DROPPINGS.
3. DROPPINGS COLLECTED IN AREAS B-1 & B-4.

E.C. MARTEN
RPT
12-3-84 THROUGH 12-7-84
INSTRUMENTATION:
CP, GM & P-11 & PAM

90


F-CELL 1ST FLOOR, SOUTH HALF AND INTERMEDIATE DECK
F = FLOOR
W = WAIST (w 3.5' AF)
H = HEAD (w 6' AF)
(D) = DIRECT
(S) = SIDEWALL
NOTE: SEE ELEVATION SIDE FOR OVERALL DATA.
TABLE
SAMPLER
DOOR
SUMP
F-1
F-2
F-9
F-8
F-22
N

224-B F-CELL:

(1.) DOSE RATE TO PERSONNEL < 1 mR/HR/HR

(2.) ONLY SELECTED AREAS SURVEYED.

(3.) ON READINGS TAKEN IN AREAS A-4, C-2, C-4, F-4, & J-2. ALL READINGS < 1 mR/HR/HR

(4.) [illegible] AREAS A-2, A-4, E-2, E-4, SUMP, H-5 & J-1.

(5.) SMEARS & DIRECT READINGS TAKEN ON FLOOR WITH FOLLOWING RESULTS:

A-2	< 200 c/m (D&S)	< 220 d/m (D&S)
A-4	500 c/m (D) < 200 c/m (S)	< 220 d/m (D&S)
E-2	< 200 c/m (D&S)	140 d/m (D) < 220 d/m (S)
E-4	< 200 c/m (D&S)	< 220 d/m (D&S)
SUMP	1000 c/m (D)	500 c/m (S) 6300 d/m (D) 6300 d/m
H-5	< 200 c/m (D&S)	700 d/m (D) 700 d/m (S)
J-1	< 200 c/m (D&S)	< 220 d/m (S)

(6.) H-3 SAMPLE TAKEN IN AREA E-3.

12-10-84 THROUGH 12-14-84
E.C KIMZEY
RPT
INSTRUMENTATION:
CP, GM & PIC, PAM & SWOOPY

22

DON'T SAY IT --- *Write It!*

DATE 1-7-85

TO ROGER A. HULTGREN

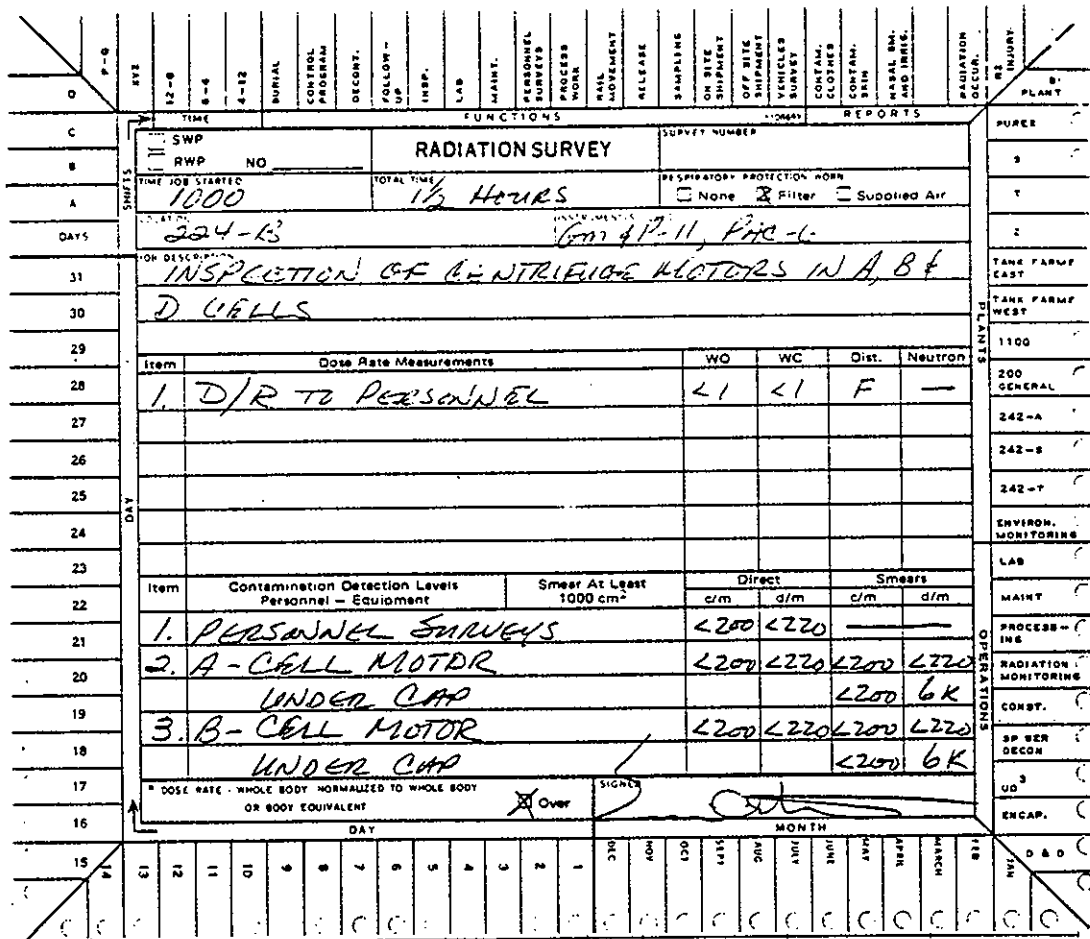
FROM E.C. MARTEN
B-PLANT
RADIATION PROTECTION UNIT

ATTACHED IS INFORMATION ON 224-B THAT YOU REQUESTED. IF THERE IS ANYMORE INFORMATION OR DATA I CAN PROVIDE FOR PLEASE DO NOT HESITATE TO LET ME KNOW. ANALYTICAL SURVEYING WILL CONTINUE DURING THIS WEEK

NOTICE DIFFERENCE IN D-CELL MOTOR FREQUENCY FROM ORIGINAL. APPARENTLY ORIGINAL SAMPLES ALSO DECONTAMINATED.

"TO MAKE LIFE LAST, PUT SAFETY FIRST"

23



SWP
RWP NO

RADIATION SURVEY

SURVEY NUMBER

TIME JOB STARTED: 1000

TOTAL TIME: 1½ HOURS

RESPIRATORY PROTECTION WORN: ☐ None ☒ Filter ☐ Supplied Air

LOCATION: 224-B

INSTRUMENTS: GM 4P-11, FAC-6

JOB DESCRIPTION: INSPECTION OF CENTRIFUGE MOTORS IN A, B & D CELLS

Item	Dose Rate Measurements	WO	WC	Dist.	Neutron
1.	D/R TO PERSONNEL	<1	<1	F	—

Item	Contamination Detection Levels Personnel – Equipment	Smear At Least 1000 cm²	Direct c/m	Direct d/m	Smears c/m	Smears d/m
1.	PERSONNEL SURVEYS		<200	<220	—	—
2.	A-CELL MOTOR		<200	<220	<200	<220
	UNDER CAP				<200	6K
3.	B-CELL MOTOR		<200	<220	<200	<220
	UNDER CAP				<200	6K

* DOSE RATE - WHOLE BODY NORMALIZED TO WHOLE BODY OR BODY EQUIVALENT

☒ Over

SIGNED

Job Details

	Direct		Smears	
4. D-CELL MOTOR	<200	<220	<200	<220

GENERAL INSPECTION OF CENTRIFUGE MOTORS CARRIED OUT WITH DIRECT READINGS AND SMEARS TAKEN ON EXTERIOR ASPECTS. MOTORS GENERALLY DUSTY BUT OTHERWISE CLEAN RADIOLOGICALLY WITH THE EXCEPTIONS AS LISTED (UNDER CAPS). SEE ATTACHED SURVEY INFORMATION FROM ARCHIVES INSPECTION FOR GENERAL AREAS.

MCBEE SYSTEMS - BELLEVUE, WA

54-6000-010 (R-10-79)

SD-DD-TRP-002

APPENDIX C

DOSE MODELING RESULTS (Letter Report)

Internal Letter

Rockwell International

Date May 14, 1985

No. 72310-85-WG-163

TO (Name, Organization, Mail Stop, Address)
K. W. Owens

FROM (Name, Organization, Mail Stop, Address, Phone)
L. N. Sutton

3-3287

Subject: Estimation of Plutonium Content in 224-B Tank D-3

The computer code BMC-MG was used to estimate the amount of plutonium inside the tank necessary to give a 0.1 mrem/hr dose rate near the tank at floor level. In order to maximize the estimated amount, it was assumed that the plutonium was evenly plated out on the inside surface of the tank wall.

The BMC-MG results indicate that the tank will contain about two kilograms of plutonium when the dose rate near it is 0.1 mrem/hr.

Since a previous estimation of the plutonium content was based on gamma exposure rates from associated Cs 137 contamination an ISOSHLD case was ran to determine the exposure rate to Cs 137 content relationship. The ISOSHLD results show that 25 Ci of Cs 137 evenly plated out on the tank walls would give an exposure rate of about 500 mR/hr at five feet from the tank. Since exposure rates of this magnitude were not detected in the cell, I would have to conclude that considerably less than 25 Ci of Cs 137 is in the tank.

If you have any questions, please call me at the above number.

L. N. Sutton
Radiological Engineering
and Effluent Controls

LNS/tjj

Att: DD-RE-LNS-045-85

cc: D. A. Dodd
J. I. Gould
D. B. Howe
P. D. Rittmann
G. J. Sliger

DD-RE-LNS-045-85 L. N. SUTTON

TITLE: 224-B PLUTONIUM ESTIMATION

PROBLEM:

Using the computer codes BMC-MG and ISOSHLD.estimate the amount of plutonium (6% Pu 240 content) and Cs137 required to be plated out on the inside of the tank walls to give a neutron dose rate of 0.1 mrem/hr and a gamma exposure rate of 1 mR/hr near the tank.

INPUT/ASSUMPTIONS:

BMC-MG

The tank is nine feet in diameter, the total wall thickness was 9/16 of an inch which was also assumed to be the thickness of the lid.

By using reflecting boundaries, it was possible to model the problem using only 1/4 of the tank. The sketch on the following page shows the physical layout. You will note that the modelled configuration is not truly representative of the actual physical configuration, but it is close enough to provide the estimate required. By modelling only the lower right hand quadrant of the tank; computer running time was reduced, accuracy was increased and conservatism was incorporated into the calculation.

The source was assumed to be a uniform coating .1 cm thick on the walls of the tank. It was modelled as a salt cake consisting of 1 g/cc plutonium, .2 g/cc oxygen, .1 g/cc calcium and .1g/cc sodium. The isotopic weight percent of the plutonium was as follows:

Pu 238	.023%
Pu 239	93.44%
Pu 240	5.87%
Pu 241	.644%
Pu 242	.021%

In addition, the plutonium was aged by BMC-MG for 10 years.
A total of 25860 grams of plutonium was assumed to be in the tank.

As the sketch shows, the doses were calculated at three points. These points were 15 cm above the floor.

ISOSHLD

IGEOM 12 was used to model the tank, the walls were 1.2 cm thick iron, the source was modelled as water with a SpG of .9 g/cc and the buildup factor was baesd on iron. The exposure rates were calculated at distances of 2 and 5 feet from the tank assuming that there was .5 Ci Cs137 plus .474 Ci Ba137m in the tank.

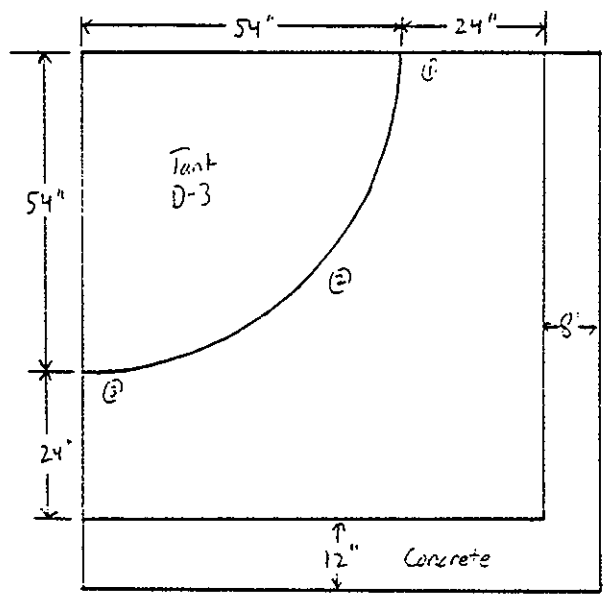
RESULTS:

The BMC-MG results were 1.3, 1.6 and 1.4 mrem/hr for dose points 1,2 and 3 respectively. The ISOSHLD results were 22 and 10 mR/hr at 2 and 5 feet respectively.

 Checked By: [signature]

SD-DD-TRP-002

DD-RE-LNS-045-85 L. N. SUTTON



 Checked By Karen Gaffke

DD-RE-LNS-045-85 L. N. SUTTON

CONCLUSIONS:

Before making any conclusions, it would be useful to give some more background information on the problem. It had been previously estimated that tank D-3 contained approximately 25 Ci of Cs137. A plutonium content of 33 kg was extrapolated from the Cs137 estimate using relationships between Cs and Pu concentrations developed from sample analysis. Actual dose and exposure rate measurements were taken in cell D of 224-B. They indicated neutron dose rates of about .1 mrem/hr near the tank and exposure rates of 1 mR/hr at about 5 feet from the tank.

The BMC-MG results would seem to indicate that a neutron dose rate of .1 mrem/hr near the tank equates to a plutonium content of 1.8 kg. On the other hand, if the tank contained 25 Ci of Cs137 then the ISOSHLD results would indicate an expected exposure rate of 500mR/hr at 5 feet from the tank.

Based on the computer results, it appears that the estimation of the plutonium content in tank D-3 is high by a factor anywhere between 20 and 500.

 Checked By Dawn Kirkbride

SD-DD-TRP-002

APPENDIX D

D-3 TANK REPEAT MEASUREMENTS (Letter Report)

Internal Letter

Rockwell International

Date. June 7, 1985

No. . 65452-85-102

TO: (Name, Organization, Internal Address)
- K. W.Owens
- Waste Management Systems Engineering
- 2750E/D268/200 East Area

FROM: (Name, Organization, Internal Address, Phone)
- J. I. Gould
- Analytical Process Development
- 202S/200 West Area
- 3-2125

Subject: . Tank D-3 Reevaluation Measurements

Ref. Letter, 65452-85-085, May 15, 1985, J. I. Gould to K. W. Owens, "Work Plan for Additional D-3 Tank Measurements"

SUMMARY

Several measurements were made in the D cell following the general guidelines in the referenced test plan. The purpose of the measurements was to reevaluate the earlier estimates of the D-3 tank radionuclide inventory. These estimates had exceptionally high quantities in both TRU and non-TRU components. The Analytical Process Development Unit (APDU) and the Radiological Protection Department (RPD) performed the repeat measurements in the D cell.

The latest measurements demonstrated that the radioactive residue inside the D-3 tank is neither uniform in isotopic ratio nor uniform in its distribution. Measurements with a neutron-dose instrument (SNOOPY) confirm that the upper limit of 1.7 kg of TRU estimated by the Radiation Protection Engineering (RPE) Group is reasonable.

Measurements by pressurized ion-chamber for (gamma) exposure rate confirm that locations within the D cell are all less than 20 micro-R/hr. Measurements with the Mobile Radionuclide Analysis Laboratory (MRAL-II) indicate wide variations in the three primary radionuclides, cesium-137, americium-241, and plutonium-239. New smear samples were taken from the D-3 tank flanges. Ratios of TRU to cesium-137 based on these samples were nearer the general facility-wide averages first used to estimate the tank inventory. Ratios from the in-place measurements, however, indicate a higher TRU to cesium-137 ratio.

Based on this most recent set of measurements, the D-3 tank inventory is estimated at:

- Cesium-137 = 1.1 mCi (upper limit of 2.7 mCi)
- Americium-241 = 3.4 Ci (upper limit of 6 Ci)
- Plutonium-239 = 7.4 Ci (upper limit of 23 Ci).

The APDU suggests that individual insertion measurements be made into the D-3 tank, as well as the F-7, F-8, and F-9 tanks when D&D begins.

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DISCUSSION

Measurements

We reentered the D cell on May 16, 1985. The RPD technician, Walter Nelson, first made 16 measurements with a neutron dose meter (SNOOPY) at eight locations around the D-3 tank. For each positional location, measurements were made at both waist and floor heights. Measurements were also made at two locations around the D-4 tank and at four positions around the D-1 tank. The smallest marked increment on the readout dial of the SNOOPY was 0.1 mrem/hr. All of the SNOOPY readings were less than this smallest increment. The instrument was later taken to the 200 East Area tank farms operations office and its operation verified using a neutron source. The instrument was in current calibration and was not due for calibrational service for at least one more month. This series of measurement provided confirmation for the modeling calculations performed by the RPE.

The APDU made ion-chamber measurements of the exposure rate at four locations around the D-3 tank, two locations around the D-1 tank, and one location near the D-4 tank. The ion chamber was arranged on a tripod with the center of the chamber at approximately 30 inches above the floor. None of the rates exceeded 25 micro-R/hr. This was slightly higher than results from the earlier entry by APDU in which exposure rate was measured in this cell. The locations at which SNOOPY and ion chamber readings were taken are shown in figure 1. Cell references to tank location are made with respect to a clock, with twelve o'clock at due north.

The APDU used the MRAL-II borehole detector IG781010 to make four in-place measurements of the radionuclides present in the D-3 tank. The first was made outside the tank at the three o'clock position about 1.5 feet above the floor. This measurement was made with the detector uncollimated in order to maximize identification of as many photopeaks as possible in the gamma energy spectrum with a minimum of counting time. After this, three more spectra were taken with the detector outside the tank, collimated inward toward the D-3 tank.

Three smear samples were taken. Two were from a flange opened during the first characterization survey. The third was from the outside of a flange that appeared to have a white residue left from earlier operations. Analyses from the MRAL-I are shown in Table 2.

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Results

Table 1 shows the results for the three radionuclides of primary interest in the D-3 tank. Count rates were corrected for field of view, for attenuation by tne tank wall, and for various distributions of residue inside the tank.

Variations

There are wide variations in the results. The APDU examined the entire measurement method for inconsistencies in detector operation. The data variations appear to be real. The standard deviation (SD) of the D-3 tank reevaluation measurements is not much beter than the SD previously determined for the entire 224-8 facility.

In calculating the inventories for the radionuclides, the unshielded measurement (table 1, column 1) was assumed to be from a uniform flat source with a solid angle of 2-pi steradian.

The three collimated measurement results were based on an assumed flat source with two sheets (equivalent to the front and far walls of the tank). The results at eight and twelve o'clock assumed a linear gradient to zero (at the top of the tank wall) with a uniform distribution across the tank floor. The three o'clock result assumed a linear gradient to zero at the top of the tank wall, plus a second gradient to 125% of the measured concentration at the bottom of the wall and across the floor. No distribution was assumed for the ceiling of the tank. Because the assumptions differed, the inventory calculations are not exactly linear; and the count rates do not scale exactly with the inventory estimate for the three locations.

Conservative Limits

A conservative upper limit for all three radionuclides is given, by assuming:

1. From the four measurements of surface concentration, a standard deviation (SD) for the group can be estimated.

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2. The experimental errors add to this in quadrature:

   - 5% SD for the traceability of the calibration facility
   - 7% SD for the calibration measurement statistical error
   - 20% SD for the conversion from the 4-pi enclosed media to an open, nonattenuating spherical geometry
   - The eccentricity of the detector response is not a factor in the americium-241 collimated measurement, but contributes a 10% error in the cesium-137 collimated measurement.

3. Since the range of measurement results is quite large, we used only two standard deviations upward from the calculated value to establish an upper limit on the inventory.

Ratios

The variation in ratios of the radionuclides with location is consistent with a facility in which several processes have been active. The ratios of americium-241/cesium-137 found from the in-place measurement are large and indicative of the general problems found in extrapolating the tank inventory initially. The in-place measurement result is consistent with the dose and exposure data from which RPE predicted only a small amount of total TRU and fission product in the tank.

CONCLUSION

These results are consistent with the predictions of inventory made by the Radiation Protection Engineering Group. The 23 Ci maximum estimate of plutonium-239 in the D-3 tank should not pose any hazard to D&D workers if reasonable safety precautions are followed.

The large general variation of the inventory suggests that future characterization efforts should plan for a larger number of measurements into the tanks of a process facility in order to develop a precise picture of the facility inventory. It shows that activity on the outside of flanges and tanks is not necessarily representative of the concentrations inside the vessels.

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Because there have been large variations in the results for the tank inventory as a result of using several data sets to make the inventory estimate, APDU requests the opportunity to make comparison measurements in each of the tanks with the MRAL-II insertion detector when it becomes convenient to remove the top cover plate of any tank.

These results will be incorporated into the 224-B radiological characterization report as soon as possible. If you have questions, please contact me.

J. I. Gould
Scientist

JIG/pdk

Att.

cc: D. A. Dodd
J. F. Mincey
P. D. Rittmann
G. J. Sliger
J. P. Sloughter
D. R. Speer
L. N. Sutton
G. L. Troyer

Table 1. D-3 Tank Reevaluation Measurements

Species (energy)	3 O'clock (unshielded)	3 O'clock (into tank)	12 O'clock (into tank)	8 O'clock (into tank)
^{241}Am (59.5keV)	.428 cps 11.7uCi/sqcm	.038 cps 3.51uCi/sqcm	.007 cps 2.59uCi/sqcm	-0-
Total	3.44 Ci	535 mCi	560 mCi	
^{239}Pu (129keV)	.076 cps 2.27uCi/sqcm	.026 cps 124 nCi/sqcm	not meas.	.310 cps 1.05uCi/sqcm
Total	670 mCi	26.9 mCi		186 mCi
^{239}Pu (414keV)	.080 cps 2.36uCi/sqcm	.018 cps 2.12uCi/sqcm	.014 cps 4.09uCi/sqcm	.143 cps 41.8uCi/sqcm
Total	697 mCi	384 mCi	726 mCi	7.41 Ci
^{137}Cs (662keV)	.543 cps .286nCi/sqcm	.133 cps .264nCi/sqcm	.347 cps 1.73nCi/sqcm	1.05 cps 5.99nCi/sqcm
Total	84 uCi	78 uCi	306 uCi	1.06 mCi

Notes:
Data are uncorrected for interior geometry, but has been smoothed with a 5-point filter in order to get the best estimate of net count rates.

Variation in the three collimated measurements demonstrates the variable nature of deposition within the tank.

Standard deviations of the measurements are ^{241}Am, 86%; ^{239}Pu, 156%; and ^{137}Cs, 126%.

Upper limits (at 2 SD) are ^{241}Am, 5.98 Ci; ^{239}Pu, 23.1 Ci; and ^{137}Cs, 2.7 mCi.

Table 2. Analysis of Smear Samples

ID	LOCATION	Americium-241	Cesium-137	Cobalt-60
353	D-3 Tank Interior Side Fige	1940 pCi	519 pCi	<mdl #
355	D-3 Tank Interior Side Fige	1630 pCi	627 pCi	18 pCi
354	D-3 Tank Riser @ 3:00	<mdl *	34 pCi	29 pCi

Ratios of Radionuclides

Location	$^{239}Pu/^{241}Am$	$^{241}Am/^{137}Cs$
Interior Smears	NA	3.11: 1
3:00 (unshielded)	0.2: 1	4.09E+4:1
3:00 (collimated)	0.6: 1	1.33E+4:1
12:00(collimated	1.6: 1	1.50E+3:1
8:00 (collimated)	NA	NA

NOTES:
* The minimum detection limit for americium-241 in these circumstances is about 8 pCi for the entire smear.
\# The measured value here was less than the nominal background usually subtracted from each of the sample measurements.

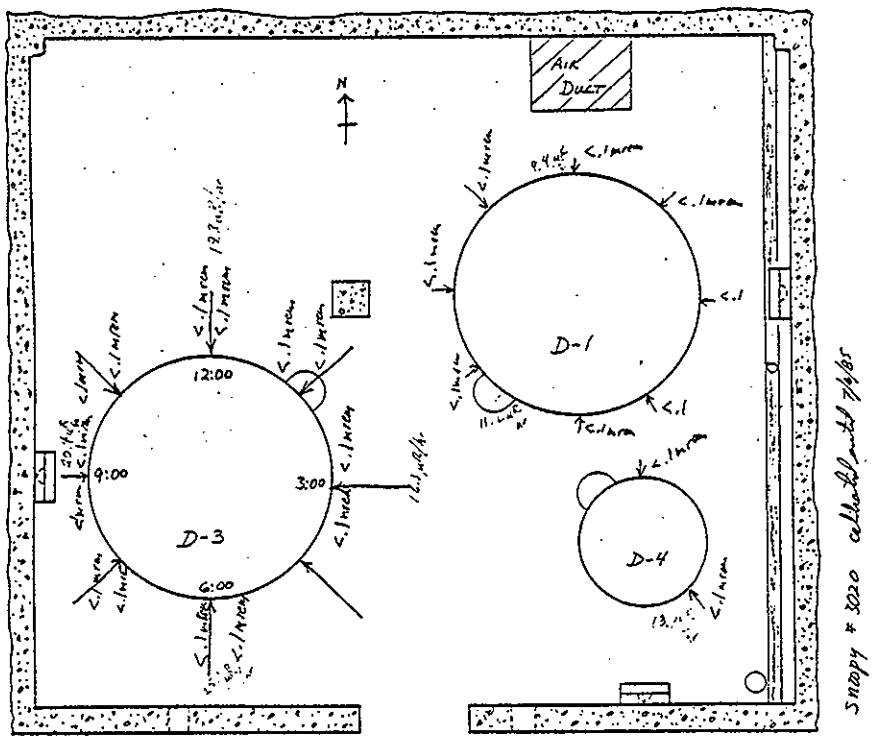

Figure 1. D-cell of 224-B Building, showing Locations of Reconfirmation Measurements on 5/16/85.

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